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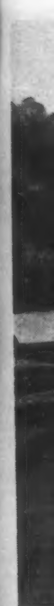

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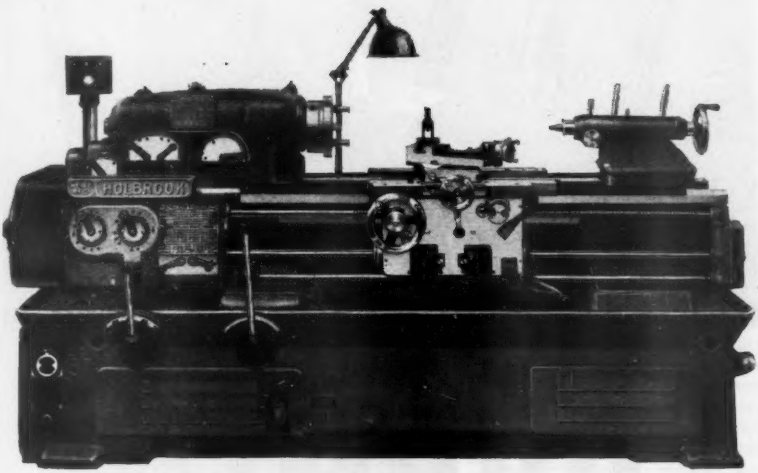

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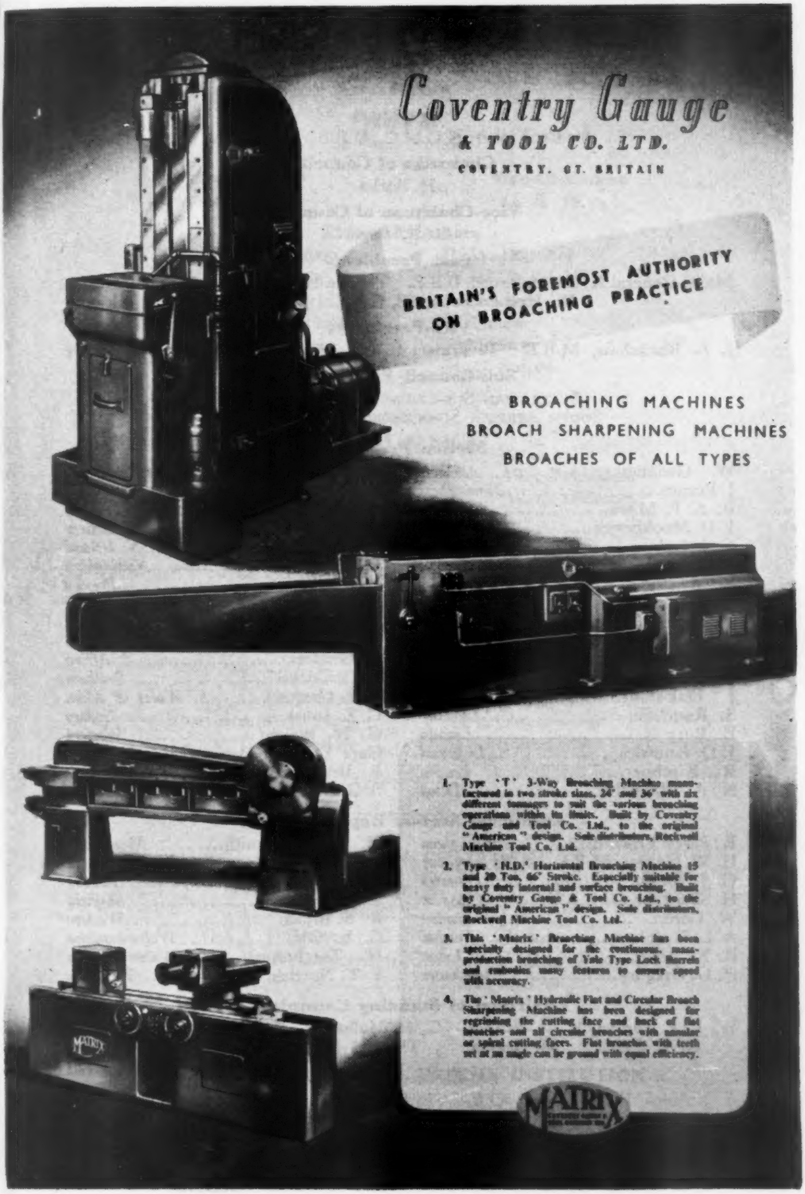
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THE JOURNAL OF

THE INSTITUTION OF PRODUCTION ENGINEERS

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Contents

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INSTITUTION NOTES

November, 1952

Northern Productivity Exhibition

Members will be interested to note that this issue of the Journal makes particular reference to the Northern Productivity Exhibition, which is being held in Newcastle-on-Tyne from 30th October until 6th November, 1952.

This Exhibition is of especial interest to the Institution in that the North-Eastern Section is making an important contribution. Mr. R. W. Mann, Past President of the Section, who was appointed Chairman of the Exhibition Management Committee, explains the aims and objects of the Exhibition in his Introduction on pages 536-539, and Sir Robin Rowell, C.B.E., A.F.C., D.L., a leading industrialist in the area, has sent a special message to Institution members, which appears on pages 540-542.

Conference on "Problems of Aircraft Production"

The Institution of Production Engineers will hold a Conference on "Problems of Aircraft Production" at the University of Southampton on Friday and Saturday, 19th and 20th December, 1952.

The Conference, which is being organised by the Southern Section Committee, will be opened by a Luncheon to be held at the University on Friday, 19th December, by Brigadier Low, Parliamentary Secretary to the Minister of Supply, and will take the form of three main Sessions, as follows :

Session I, Friday, 19th December, 2.30—4.30 p.m. *Designing for Production.*

Session II, Friday, 19th December, 5.0—7.0 p.m. *Prototype to Production.*

Session III, Saturday, 20th December, 9.30—11 a.m. *Impact of Modifications on Production.*

The Conference will be summed up from 11.30 a.m. to 12.30 p.m. on Saturday morning by Mr. Walter Puckey, a Vice-President of the Institution, who is Deputy Controller of Supplies (Aircraft Production) at the Ministry of Supply.

Members who would like to attend this Conference, are invited to make early application to the Secretary at 36, Portman Square, London, W.1.

Chairman of Council's Visit to Canada

The Canadian Section of the Institution held a special meeting at the Royal York Hotel, Toronto, in September last to welcome Mr. Harold Burke, Chairman of Council. Mr. Burke, who gave a short address, explained the organisation of the Institution in Great Britain and in other overseas Sections, and answered many questions raised by the members present, several of whom had travelled a considerable distance to attend.

This photograph was taken during the special meeting of the Canadian Section. Included are Mr. Harold Burke, Chairman of Council (*centre*), and the following members of the Canadian Section Committee:
Back row: C. J. Luby (Chairman), (*extreme l.*); S. S. Pritchard, (*3rd from r.*); W. M. Buchanan, (*extreme r.*). Centre row: F. D. H. Ronald (*extreme l.*); A. R. Jupp (*second from l.*); T. H. Beard, Hon. Secretary (*extreme r.*) Front row: H. L. Ward (*3rd from l.*)

The Institution congratulates the Canadian Section on the noticeable progress it has made, and has no doubt that the enthusiasm and initiative of the members will result in this Section playing a leading part in the Institution's future development.

S. African Branch—A.G.M. and Dinner

The Fifth Annual General Meeting and Dinner of the South African Branch of the Institution was held on Friday, 8th August, 1952, at the Victoria Hotel, Johannesburg.

In the Chair was Mr. G. Godfrey, retiring President of the South African Sub-Council, who welcomed his successor for the coming year, Mr. R. H. Arbuckle, and introduced the new Members of Council.

The Annual Report and Accounts, copies of which had been circulated prior to the Meeting, were approved and adopted, and a pleasing ceremony during the evening was the award of the President's Prize for the best paper presented by a member during 1951/52 to Mr. W. G. Gillespie, whose subject was "Thread Grinding."

This photograph, taken at the Annual General Meeting, shows (l. to r.) Mr. G. M. Pratley (Member of Council) ; Mr. R. H. Arbuckle (incoming President); Mr. D. A. Petrie (Member of Council) ; Mr. G. Godfrey (outgoing President) ; Mr. J. Ritchie ; Mr. D. Adams ; Mr. D. Lion-Cachet (Past President) ; and Mr. H. J. G. Goyns (Member of Council).

Among the many distinguished guests attending the Dinner were Mr. D. Lion-Cachet, Past President of the South African Sub-Council ; Mr. F. C. Williams, Advisory Secretary, Steel and Engineering Industries Federation of S. Africa ; Dr. A. J. Octleston, Chairman of the S.A. Branch of Structural Engineers ; Mr. J. T. Allen, President, S.A. Institute of Electrical Engineers ; Mr. L. A. Woodworth, President, S.A. Institution of Welding ; Mr. R. W. Kane, President, Institution of Certificated Engineers ; Mr. J. Ritchie, Director, S.A. Bureau of Standards ; Mr. H. A. Godwin, President, Institute of British Foundrymen ; Dr. A. W. Rowe, Director, Witwatersrand Technical College ; and Professor L. Taverner, Chairman of Mechanical Engineering, University of the Witswatersrand.

NEWS OF MEMBERS

Mr. Frank W. Ross

The many friends of Mr. Frank W. Ross, former President of the Cornwall Section will be glad to know that he continues to make progress. Mr. Ross has been seriously ill since Easter, and at the moment is still confined to bed.

His wise counsel on the Section Committee has been greatly missed.

Mr. W. G. Ainslie, B.Sc.(Eng.), Associate Member, is now Head of the Department of Production Engineering at the Wolverhampton Technical College.

Mr. F. Austin, Associate Member, has been promoted to the position of Works Manager of Hoover Washing Machines Ltd., Merthyr Tydfil.

Mr. W. T. Barry, Associate Member, has relinquished his post as General Works Manager with the Chiswell Wire Co. Ltd., Watford, and has emigrated to Australia.

Mr. F. Bloor, Associate Member, has taken up an appointment as Senior Lecturer in Production Engineering at the Royal Aircraft Establishment Technical College, Farnborough.

Mr. J. O. Bowley, Member, has resigned from the position of Works Manager, Guy Motors Ltd., and has taken up an appointment as Deputy Chief Engineer at the Ministry of Supply's Fighting Vehicles Design Establishment, Chertsey.

Mr. A. E. Capper, Associate Member, is now employed by the Northern Electric Company of Canada, Quebec, as a Plant Layout Engineer.

Mr. G. C. Davey, Associate Member, is now a Planning Engineer with Saunders Roe, Ltd., I.O.W.

Mr. E. S. Dodd, Associate Member, has taken up an appointment as a Process Engineer with Asea Electric Ltd., Walthamstow.

Mr. N. Fisher, Associate Member, has been appointed Planning Engineer at Shannon Ltd., Malden.

Mr. J. France, Chairman of the Education Committee, has been nominated as the Institution's representative on the Governing Body of the Institute of Technology, Loughborough College ; this nomination was made at the request of the Ministry of Education. Mr. France recently took up an appointment as General Manager of the Liverpool Factory of the Lockheed Hydraulic Brake Co. Ltd.

Mr. E. F. Gilberthorpe, Member, has been appointed a Director of his Company, S. M. Wilmot & Co. Ltd., Bristol.

Mr. F. J. Harlow, Int. Associate Member, is now Manager of the Government Training Centre, Manchester.

Mr. L. Harris, Associate Member, is now employed as a Production Engineer at the Naval Ordnance Department, Bath.

Mr. E. H. Hughes, Associate Member, has taken an appointment as Works Manager with Boyriven (Hardware) Ltd., London.

Mr. D. A. Jones, Associate Member, has transferred from Girling Ltd., Cwmbran, Monmouthshire, to the new Lucas/Rotax Company Ltd., Toronto, Canada.

Mr. A. G. Lee, Associate Member, is now Inspector-in-Charge, A.I.D., at Rolls-Royce Ltd., Derby.

Mr. R. A. Lowe, Associate, Principal of the firm of R. A. Lowe & Partners, Machine Tool Consulting & Inspecting Engineers, Reading, is now also a partner in the firm of Cromwell Precision of Reading, Manufacturing Engineers.

Mr. C. J. Martin, Associate Member, has taken up an appointment as Technical Representative for the Northern London area of Deloro Stellite Ltd., Birmingham.

Mr. R. Mishra, Associate Member, has taken up an appointment as a Lecturer in Production Technology at the Indian Institute of Technology, Khargpur.

Mr. E. E. Neary, Associate Member, has now joined the staff of the Central Engineering Department of Ilford, Ltd., London.

Mr. H. J. Nixon, Member, has taken an appointment as Works Director of Alvis, Ltd., Coventry.

Mr. S. M. Patil, Associate Member, has been promoted to the post of Works Manager with Cooper Engineering Ltd., Satara Road, Bombay State, India.

Mr. P. J. Quincey, Associate Member, has taken an appointment as Works Manager with Pegson Ltd., Coalville.

Mr. T. D. Rao, Associate Member, is now Chief Engineer, Rashtriya Metal Industries Ltd., Bombay.

Mr. N. H. Soulsby, Associate Member, has been appointed Works Manager of Entwistle & Gass Ltd., Bolton.

Mr. H. Taylor, Associate Member, has joined Walker & Schofield Ltd., Oldham, as Chief Tool Designer.

Mr. M. W. Alderdice, Graduate, has taken up a position as Works Manager of Valpaluse Ltd., Halifax.

Mr. W. M. Bull, Graduate, has taken a post as Planning Engineer with the British Oxygen Engineering Division, Edmonton, London.

Mr. John Chambers, Graduate, has taken up an appointment as a Planning Production Engineer with Simplex Electric Co. Ltd., Blythe Bridge, Staffs.

Mr. S. H. Day, Graduate, has now taken up the post of Senior Jig & Tool Draughtsman with the Bristol Aeroplane Co. Ltd., Engine Division.

Mr. L. Francis, Graduate, has taken up a position as Senior Planning Engineer with A. V. Roe (Canada) Ltd., Toronto.

Mr. H. F. Gadd, Graduate, has been appointed Assistant Lecturer (Engineering) at the Technical Institute, Khartoum, Sudan.

Mr. D. Gutteridge, Graduate, is now employed as a Jig & Tool Draughtsman with F. N. F. Ltd., Textile Engineers, Burton-on-Trent.

Mr. C. W. Haigh, Graduate, is now employed as a Jig & Tool Draughtsman at D. Napier & Sons Ltd., Liverpool.

Mr. John G. Hyland, Graduate, has taken a post as Technical Advisor with Roneo-Neopost Ltd., London.

Mr. Maurice W. G. Lewis, Graduate, is now a Junior Assistant Engineer with Standard Telephones & Cables Ltd., North Woolwich.

Mr. N. P. Spence, Graduate, is now a Designer/Draughtsman, with Orwood Tools Ltd., Leeds.

Mr. T. Thompson, Graduate, is now a Works Study Officer at the Kynoch Works of I.C.I. Ltd.

International Machine Tool Exhibition

This photograph taken at the International Machine Tool Exhibition, Olympia, shows Mr. W. F. S. Woodford, Secretary, and Mr. S. Caselton, Assistant Secretary (Administration), receiving members on the Institution's stand.

M.S.A. Scholarships

Mr. H. A. Gordon, Associate, Mr. Eric Ward, Associate Member, and Mr. J. Metcalfe, Graduate, have been awarded post-graduate scholarships by the Mutual Security Agency, to study Production Technology and Management in the United States.

British Standards

The following British Standards have recently been issued and may be obtained, post free, from the British Standards Institution, 24-28, Victoria Street, Westminster, London, S.W.1 :—

B.S. 143 : 1952 Malleable cast iron and cast copper alloy pipe fittings for steam, air, water, gas and oil, screwed B.S.P. taper thread or API line pipe thread. (7/6)

B.S. 953: 1952 Strength tests for the protective toecaps of footwear used for industrial purposes. (2/6)

B.S. 1256 : 1952 Malleable cast iron (whiteheart process) and cast copper alloy pipe fittings for steam, air, water, gas and oil, screwed B.S.P. taper male thread and parallel female thread. (7/6)

B.S. 1489 : 1952 Reels for covered, solid, round winding wires for electrical purposes. (2/6)

B.S. 1870 : 1952 Men's safety boots and shoes. (2/6)

B.S. 1886 : 1952 Terms and definitions for single-point cutting tools for lathes, boring-mills, planing, shaping and similar machines. (6/-)

B.S. 1888 : 1952 Precision reels for bare and oxidised resistance wires. (2/6)

B.S. 1891 : 1952 Sizes of single-ply paper bags. (2/6)

HAZLETON MEMORIAL LIBRARY

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when borrowing books.

REVIEWS

725.4 **INDUSTRIAL BUILDINGS**

"The Modern Factory" by Edward D. Mills. *Architectural Press, London.* 1951. 190 *pages. Illustrated. Diagrams.* 30/-.

For the industrialist this is a practical book which places at his disposal a wealth of architectural experience. It is full of useful, simply presented, information concerning the siting and design of factories and ancillary buildings and relates these to the processes which they are to house. A number of excellent line diagrams and working check lists are included in the text, which is well illustrated by drawings and photographs of interesting modern industrial buildings at home and abroad.

A section of the book of considerable interest to the industrialist who is fortunate enough to have permission to build, is that dealing with the authorities who must be consulted before a site is chosen. These present a formidable list.

A comprehensive bibliography is appended.

B.E.S.

657.47 COSTING

"Dictionary of Costing" by R. J. H. Ryall. (3rd Ed.) *Pitman, London.* 1952. 484 *pages. Charts.* £1 10s. od.

Whatever the term or expression used in the field of costing today will be found in this excellently produced Dictionary.

Each term or expression is covered in detail either by a paragraph or several pages. As an example, the phrase "Mechanisation of Accounts" is covered by 23 pages with many illustrations of the latest mechanical and electrical accounting machines, together with considerations for installing such a system.

All the well-known incentive schemes are covered under their titles and liberal use of illustrations and charts, together with examples of the various terms used, serve to amplify the well written text.

A great asset are the three sections of the Index, Formulae, Charts and Forms, which enables a sample of any one of them to be looked up at a moment's notice without reference to the text.

It would be difficult to imagine a word or expression to which reference is not made in this Dictionary.

It should prove useful to all engaged in Production Engineering, whatever their sphere.

D.H.M.

621.791 WELDING

"The Welding of Non-Ferrous Metals" by F. G. West, Ph.D., B.Sc. *Chapman & Hall, London.* 1951. 553 *pages. Illustrated. Diagrams.* £2 15s. od.

The author of this excellent book is a well-known authority on light alloys; he has also been directly engaged on research work in welding at a time when he was senior investigator with the British Non-Ferrous Metals Research Association. He is, therefore, well qualified to produce a book on this subject, which, as the author says in his preface, is aimed at two main classes of reader. These are the welding engineer, operator, instructor or trainee in one group, and the designer, works engineer or metallurgist in the other.

The work is comprehensive in character; the first five chapters deal with general matters and with welding processes, and the remaining nine are concerned with individual non-ferrous metals and their welding characteristics; there is an interesting foreword by Dr. L. Aitchison.

Recognising that the book cannot be both comprehensive and exhaustive, the author has provided a large bibliography of more than 350 references for those who wish to specialise. As is natural, in view of the author's interests, the welding of aluminium occupies by far the greatest space devoted to any one metal or group of metals—23 per cent of the whole book.

In the formulation of the conditions of the production of a weld, metallurgical knowledge is the dominant factor. This is the basis of the author's approach, and every technique derives naturally from the relevant metallurgical background of the metal or alloy under consideration.

It is a metallurgically based, readable and well documented lucid general guide to its subject, and will obviously become a standard work.

F.A.F.

ABSTRACTS

330. ECONOMICS

"Engineer's Approach to the Economics of Production" by John Reid Dick. *Pitman, London.* 1952. 248 *pages.* 21/-.

The author, as an introduction to his subject, states the reasons why an engineer should interest himself in economics and illustrates the benefits which can accrue from such knowledge, even by those engaged in pure engineering research.

The fundamental laws of economics are explained, and their operation and results contrasted with certain engineering principles with which the reader might be more familiar.

Emphasis is made of the need for promoting increased industrial efficiency by analysing the determinants of efficiency for each of the production factors; distinguished in the book as land, capital, energy and labour.

331. LABOUR

"Manpower: A Series of Studies of the Composition of Britain's Labour Force". *P.E.P.* (*Political and Economic Planning*), *London.* 1951. 102 *pages.* 15/-.

The introduction consists largely of statistical tables of the labour force of Great Britain, and is followed by the first study size of the labour force, male and female, with future trends.

Distribution of the labour force is given under the headings: occupational, geographical, and industrial.

The third study, employment of women, makes particular mention of part-time work. Entry into employment emphasises the Youth Employment Service, and the part to be played by the employer.

The final study deals with the Educational Training of wage-earners from general and vocational education of boys and girls, to training within firms, and concludes with the training of supervisors.

331.15 INDUSTRIAL RELATIONS

"Productivity and Trades Unions" by F. Zweig. *Blackwell, Oxford.* 1951. 240 *pages.* £1 1s. 0d.

The book is an exposition of facts gathered from a study of five industries —Building, Cotton, Steel, Printing and Engineering, enlightening an enquirer concerning Trade Union histories, structures, functions and attitudes, the relation of these to Management and their influence upon productivity. The diversities of these features and of traditions, practices and deviations from rule in the many Unions, present a situation of such exceptional complexity that, without thorough knowledge of all factors relevant to any industry, opinion may be easily misled and action misdirected.

The author presents factual evidence invaluable to the forming of conclusions, e.g. upon restrictive practices, incentives, and the effect of full employment, while himself avoiding expression of opinion, so that the book may be used as a means towards a broad understanding of the subject as a whole or as a text-book in the consideration of detail concerning any of the five industries treated.

OTHER ADDITIONS

621.888 SPRINGS

Roberts, John A. **"Spring Design and Calculations."** (5th Ed.) *Redditch, Herbert Terry and Sons Ltd.* 1951. 126 *pages. Diagrams.*

621.9 MACHINE TOOLS; MACHINING

Aluminium Company of Canada Ltd., Montreal. **"Machining Aluminium."** *Montreal, The Company.* 1948. 58 *pages. Illustrated. Diagrams.* (Alcan technical books.)

American Brass Co., Waterbury, Conn. **"Practical Suggestions for Machining Copper, Brass, Bronze and Nickel Silver."** (4th Ed.) *Waterbury, The Company.* [1951.] 32 *pages. Illustrated. Diagrams.* (Anaconda publication B–3.)

Ernst, Hans. **"Fundamental Aspects of Metal Cutting and Cutting Fluid Action."** *Cincinnati, Cincinnati Milling Machine Co.* 1951. *pages* 936–961. *Illustrated. Diagrams.* (New York Academy of Sciences —Annals, Ser. 2, Vol. 53, No. 4.)

Groom, J. H. **"Maintenance and Servicing of Hydraulic Units for Machine Tools."** *Cincinnati, Cincinnati Milling Machine Co.* 1950. 16 *pages. Illustrated. Diagrams.*

"Hydraulic Operation of Machine Tools." (4th Ed.) *Brighton, Machinery Pub. Co.* 1952. 64 *pages. Illustrated. Diagrams.* 4/–. (Machinery's Yellow Back series No. 10.)

International Nickel Co. Inc., New York. **"Machining of Nickel Alloy Steels."** *N.Y., The Company.* 1946. 24 *pages. Diagrams.*

Metal Cutting Tool Institute, New York. **"Machining of Stainless Steels."** *N.Y., The Institute.* 1951. 27 *pages. Diagrams.*

621.97 PRESS WORK

Aluminium Company of America, Pittsburgh, Pa. **"Forming Alcoa Aluminium."** *Pittsburgh, The Company.* 1951. 77 *pages. Illustrated. Diagrams.*

Aluminium Company of Canada Ltd., Montreal. **"Forming Aluminium."** *Montreal, The Company.* 1949. 123 *pages. Illustrated. Diagrams.* (Alcan technical books.)

657. ACCOUNTANCY

National Screw Machine Products Association, Cleveland, Ohio. **"Basic Principles of Cost Control for the Screw Machine Products Industry."** (2nd Ed.) *Cleveland, The Association.* 1951. 32 *pages. Charts.* $5.00.

658. INDUSTRIAL ORGANISATIONS; MANAGEMENT

Billington, P. H. **"Factory Management."** *Manchester, Emmott & Co. Ltd.* 1946. 111 *pages.* 3/6. (Mechanical World Monographs.)

Beacham, A. **"Economics of Industrial Organization."** (2nd Ed.) *London, Pitman.* 1951. 189 *pages.* 15/–.

658.54 TIME AND MOTION STUDY

Franck, Pierre. **"La Mesure du travail en France: rapport du 9e Congrès international de l'organisation scientifique à Bruxelles en 1951."** *Paris, Bureau des Temps Elementaires.* 1952. 84 *pages. Charts.* 14/–.

658.562 INSPECTION; QUALITY CONTROL

Great Britain—Admiralty—Dept. of the Engineer-in-Chief of the Fleet. **"Notes on Inspection Organization and Dimensional Control."** *Bath, The Department.* 1952. 76 *pages. Diagrams. Mimeographed.*

658.58 MAINTENANCE

Denner, F. D. **"Planning Factory Maintenance."** *Manchester, Emmott & Co. Ltd.* [n.d.] 29 *pages.* (Mechanical World Monographs.)

The Library Members are asked to note that the Library will be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week, and from 9.30 a.m. to 12.30 p.m. on Saturdays. Due to Meetings, the full facilities will not be available at the following times:

Tuesday, 11th November, from 12 midday.

Thursday, 13th November, all day.
Tuesday, 18th November, all day.
Tuesday, 25th November, from 12 midday.

Journal Binders

Members are reminded that binding cases for the Journal are obtainable from Head Office, price 7/6 each post free. The cases, each of which will hold 12 issues of the Journal, are made of stiff board covered with imitation leather cloth, with gilt lettering on the spine.

Research Publications

A number of copies of the following Research publications are still available to members, at the prices stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research & Development	10/6
Practical Drilling Tests	21/-
Test Charts for Machine Tools, Parts 1, 2, 3, 4	6/- each

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge," Melton Mowbray, Leics.

Issue of Journal

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Important

In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

An Introduction to

THE NORTHERN PRODUCTIVITY EXHIBITION *

by R. W. MANN, M.I.E.E., M.I.Prod.E., M.I.Min.E. †

Chairman of the Exhibition Management Committee

LET me begin by explaining how and why the Exhibition is being held.

Following an Exhibition arranged by manufacturers in conjunction with the Institution of Production Engineers in Birmingham, in 1951, it was felt by the Information Division of the Treasury that an officially sponsored trial Exhibition would be nationally worthwhile, especially if it could be arranged to show the results of productivity rather than the machinery to effect it.

The Information Division, in conjunction with the United States of America Mutual Security Agency, who bear half the cost, decided that the first of such Exhibitions should be staged on the North-East Coast where shipbuilding, coal mining, heavy and light engineering industries, with a diversity of other trades, seemed to offer reasonable scope. Consequently, the Northern Regional Board for Industry was asked to sponsor such an Exhibition in conjunction with the local Central Office of Information. As the then local President of the Institution of Production Engineers, I was invited to take over the Chairmanship of the Management Committee, whose duty it was to give effect to the Exhibition itself.

Mr. R. W. Mann

The Basis of the Exhibition Let us first of all clearly understand the basis on which the Exhibition has been designed, which is :

" To foster the interest of both employers and employees in the art of Productivity ; it is not the purpose of the Exhibition

* At Northumberland Baths Hall, Northumberland Road, Newcastle-upon-Tyne.

† Managing Director, Victor Products (Wallsend) Ltd., Wallsend-on-Tyne.

to instruct, but rather to show what has been done and can be done by employers and employees of this area in the hope that the national interest will be served by example."

Then let us understand the spirit in which the Exhibition is being held, by stating our understanding of productivity, for which we have used an extract from a speech of a past President of the Institution of Production Engineers, Major-General K. C. Appleyard, C.B.E.—" Productivity—a restless and chronic dissatisfaction with everything as it is and an incessant urge towards improvement and betterment."

In this way we have produced an Exhibition which primarily is based upon a desire for better and better relationships between employers and employees on which all productivity must ultimately depend.

Throughout the Exhibition we have attempted to hold the balance fairly between the rights and obligations of both parties, with a tendency to underline the obligations. Here on one hand we have shown examples of the employers' contribution in the way of working conditions, welfare, pension schemes, adequate incentives and the like. On the other hand, the employees' contribution by way of works committees, works suggestions and freedom from restrictive practices.

In this sense we have dealt with the office boy to the Managing Director each as a partner in a productivity team.

From here, naturally, we have gravitated to the more practical aspect of productivity. Firstly, the education of future management and employees by an adequate contribution from the University and Technical Colleges, with a section devoted to the contribution of The Institution of Production Engineers itself. Then on to a costing and production section which must, in our opinion, be the " father " and " mother " of modern productivity, and next, the Works Study section dealing with Material and Methods.

Each of the two foregoing sections is prefaced by a suggested correct method of approach and supported by practical examples collected from firms within the area, showing the percentage of increased productivity obtained therefrom.

Naturally in such an Exhibition covering all local industry, and not limited to engineering, there must be included a series of indirect adjuncts to productivity and the following list is an indication of the attempted scope :

Institution of Production Engineers Panel
Apprentices
Anglo-American Mutual Aid
Local Mutual Aid
Incentives

The Nationalised Industries
Lighting
Safety and Health

Finally, the centre of the Exhibition space has been devoted to working demonstrations covering a range of industries, together with the contribution of modern isotopes to industry.

No single exhibit is an advertisement to any individual firm, and the only acknowledgement to a whole host of people who have come forward gladly in the national interest, is a small " credit " panel at the end of the Exhibition. It is here that I would like to express through the pages of the Journal of the Institution, my personal thanks, as a Member of the Institution, to those Production Engineers who have helped me handle what has proved to be an exceedingly difficult job.

Aims and Objects With the Exhibition *fait accompli*, it is not unreasonable to consider for a moment what we would expect it to achieve.

It is freely said in official circles that our American cousins produce twice as much per man hour as we do, and work considerably harder into the bargain. It is no purpose of this Exhibition to prove such a state of affairs, because within the range of British industries employing between 100 and 3,000 employees, and engaged in traditional British production, such a claim is manifestly untrue.

Having just made a tour of the United States of America covering such a range of factories, for the express purpose of making comparisons, I am completely confident of three things.

(1) The American factory employee works 40 hours per week, as against our 44-hour week.

(2) He does not work any harder and, in fact, in badly organised factories he works less hard than our own people, largely because there is not the same sense of discipline.

(3) There is nothing within this range of factories in the U.S.A. that cannot be equalled by the best of our own in tooling, general efficiency, or output per man hour.

It is, therefore, the first purpose of this Exhibition not to trade " Americanisms " but to show as an example, the best of our own.

It is my firm conviction that if we care to make the necessary effort to bring our worst factories up to 75 per cent. of our best, not only will the Chancellor of the Exchequer's request for an increased output equal to three hours per week per worker be far exceeded, but that we as a nation could quickly re-establish ourselves as the major world producing force.

But let us at least face facts. On the American side there is a far wider acceptance of the employees' share in the gains from joint productivity and very much more willingness to accept teamwork as an essential. Here in this country—and I say this with 35 years of engineering production experience behind me—we are far too ready to assume that productivity within the factory is the job of the man next door, and not the concern of our own factory.

In an attempt to direct the thought to where it belongs, I say deliberately that there is no single factory operating under normal British practice of "batch production" rather than "mass production" which could not, with a suitable team spirit between itself and its workpeople, raise its productivity 25 per cent. over a reasonable period of time.

Accepting our Obligations

The job is that of Management and the Production Engineer; let us see to it that each of us accepts our obligations. And before we hedge on such an obligation may I be allowed, in conclusion, to repeat some words of H.R.H. The Duke of Edinburgh, spoken as the first Hon. Member of the Edinburgh Chamber of Commerce and Manufacturers:

"I am afraid our "no-men" are a thousand times more harmful than the American "yes-men." If we are to recover prosperity we shall have to find ways of emancipating energy and enterprise from the frustrating control of constitutionally timid ignoramuses.

"There is a school of thought which says 'What was good enough for my father is good enough for me.' I have no quarrel with this sentiment at all, so long as it is not made an excuse for stagnation, frustration and inefficiency, and I am quite sure that our fathers would be the first to agree with this."

A MESSAGE FROM THE NORTH

Sir Robin Rowell, C.B.E., A.F.C., D.L., Chairman of Messrs. R. W. Hawthorn, Leslie & Co., Ltd., voices the feelings of those engaged in heavy industry on the North-East Coast, in this special message to members of the Institution of Production Engineers. Apart from the period of the First World War, which he spent mainly with the R.F.C. and finally as senior Experimental Pilot to the Air Ministry Technical Department, Sir Robin has spent all his life in ship and engine building and his Company is one of the largest in the North. He takes a deep and active interest in every aspect of shipbuilding and has held high office in every major organisation connected with the industry.

GREATER PRODUCTIVITY—the result of an incessant urge towards increased achievement for the benefit of ourselves and the world—such is the theme of the Northern Productivity Exhibition. Its aim is to appeal to management and worker alike to make the most of our undoubted skill, and what better place to hold such an Exhibition than on the North-East Coast, where for generations outstanding enterprise and skilled workmanship have so greatly enriched the whole nation?

An intense desire for better conditions must undoubtedly have been in part the inspiration of such inventors as Sir Humphrey Davy, inventor of the Davy Safety Lamp, etc., Stephenson with his first practical steam engine, Swan, the inventor of the electric lamp, and Sir Charles Parsons, designer of the steam turbine.

To this list might be added many more famous names of those who were responsible for the development of our industrial past ; but it is not sufficient that we as a nation should rely on the efforts of our predecessors. Our present was their future, and it is always towards the future that our energies should be directed.

Responsibility of Heavy Industry

We of Great Britain need a far greater output of goods at prices competitive in world markets if we are to sustain, let alone improve, the standard of living for us all. Clearly the Chancellor of the Exchequer is looking to the shipbuilding and engineering industries to lead the way. He will, I am sure, not look in vain as far as the North-East Coast is concerned.

We have lost none of our predecessors' strong sense of responsibility, and whilst today Northern industries have become more varied, and many firms in the light engineering industry are establishing names for themselves, the heavy industries still remain the backbone of this area.

The North-East Coast of England, stretching from Blyth in Northumberland to the Tees, and including the Tyne and the Wear, is the largest home of shipbuilding in the world. Since the days of the Vikings and their long boats, shipbuilding has been in the blood of our people. Merchant ships have sailed from our berths to trade on the seven seas ; specialised craft have been planned and built ; famous passenger liners such as the late " Mauretania " have begun their lives here. In warship building, the district has always been in the van. " King George V," " Anson," Kelly," " Saumarez," are only a few of the famous warships who were cradled in North-East shipyards.

Tyneside shipbuilders were pioneers with both turbine and oil-burning ships. Their early specialisation in tanker construction has stood them in good stead in these days of ever-increasing demand for tanker tonnage.

The district has always had a just pride in the skilled craftsmanship to which its ships are an abiding witness. And if we prefer the older words ' work ' and ' craft ' to ' productivity ', our meaning is the same and we believe our results are not altogether unpraiseworthy.

Technical Development

In shipbuilding and marine engineering, as in all progressive industries, technical development both in design and methods of construction are proceeding apace. Since ships are the largest single units bought and sold, they comprise all manner of articles manufactured by widely varying trades. Thus within our shipyards we find departments which, though not large in themselves,

bear an important complementary relationship to the main steel structural shops. It is, therefore, obvious that just as machine tools of all kinds are being continually improved, so also are the plant and machinery within our shipyards. Development is indeed more rapid today than ever before. The riveted steel structure is passing, and electric welding is gaining pre-eminence.

The effect of this change so far as shipbuilding is concerned means that the steel structures have not merely to be joined together in an alternative way, but they should if possible be welded under cover in the sheds and transferred in large units into position upon the building slips ; the building of the ship itself has to be completely replanned, as also the lay-out of fabricating sheds and the re-craning of the building berths.

Far greater attention must be devoted today to the sequence in delivery of steel materials and to their accurate and efficient assembly, if ships are to be built in accordance with British traditions.

Taking Advantage of Improvements

The necessity for new equipment applies not only to the main steel structure but also to the supplementary shops—the Joiners' and Polishing, Plumbers', Electricians', Blacksmiths' and Engineering Shops—all must take full advantage of the improvements that have been made in the design of machines. Nor can power hand tools be allowed to lag behind in efficient modernisation. It must always be borne in mind when modern plant is installed that unless those responsible for using it are capable and versatile in their ideas, the utmost advantages will not be wrested from each implement.

There was a time when over a large period of years our tradesmen regarded methods learned during apprenticeship as the right and correct ways of carrying on their trade thoughout their lives, but that day is passing. We see on all sides signs of anxiety to be able to operate modern equipment, and to have even better machines in the future. Just as in our daily shopping we seek the best bargains, so must our productive methods be always the most economical, and the economical method is invariably that which mostly lightens the daily task of the operative.

I welcome the purpose of the Exhibition and I welcome the interest of the members of The Institution of Production Engineers in the effort of the North-East Coast.

EDUCATION FOR PRODUCTION ENGINEERING IN THE NORTH-EAST

by T. B. WORTH

Education Officer to the Institution

THE Northern Productivity Exhibition provides a welcome opportunity to pay tribute to an area outstanding in the classical engineering function of the ' Art and Science of harnessing the forces of nature for the benefit of mankind.'

From the beginning of the industrial revolution, firms whose names have become household words have been well to the fore in the application of scientific discovery. Consequently, the tradition of technical education there is a long one, and it has naturally centred on subjects such as Marine Engineering, Naval Architecture, Metallurgy, Mining and Civil, Mechanical and Electrical Engineering.

Two Important Factors

The character of the industry in the Tyneside area remains predominantly ' heavy.' but there are two factors which dictate a re-assessment of the educational opportunities of the area if a balanced flow of well-trained technicians and technologists is to be assured for industry.

The first factor is common to all manufacturing activities and arises from the increasing application of science to the processes of production. It affects the structure of courses in Technical Education and embraces the training of all young men whether destined for technological work or management, or both. This acceleration in the application of science to manufacture, commonly accepted as still not rapid enough to maintain our place in the commerce of the world, coupled with the need for a rationalisation and refurbishing of our means of manufacture, revealed some years ago a gap in the structure of technical education. Consequently, in 1942, courses in Production Engineering were developed and are now offered in forty-eight major technical colleges throughout the country.

Production Engineering, too often incorrectly interpreted as applicable only to what are loosely termed mass-production industries, embraces principles necessary for efficient production in most spheres and in particular, in those which achieve the end product by the application of machinery and the use of scientific method.

It is sometimes forgotten that the principles of good tooling, standardisation, prefabrication and the handling of material can be, and are, applied to the manufacture of comparatively small quantities and to the building of large units.

The second factor results from the development within the area of a considerable amount of lighter industry. The need for men trained in Production Engineering in the heavy industries may not be so apparent generally as the need in lighter industries, but the combined demand must be considerable and requires for its satisfaction a flow of trained men with the right attitude of mind towards the vital economics in the efficient use of materials, and their conversion into goods and equipment of all kinds.

This does not imply a weakening of the traditional pattern, but a strengthening through the provision of different types of training. Let us see what provision has been made for this in the North.

Northern Developments

The Northern Advisory Council for Further Education acts as the co-ordinating and advisory body for the various educational institutions in an area extending from the West Coast to the East Coast. The Tyneside area, being one of considerable industrial density, naturally makes a large proportion of the technical educational provision with which the Council is concerned.

The Council, whose constitution was largely the work of Lord Eustace Percy to whom industry and education owe so much, has representatives from the University of Durham, Establishments for Further Education—Technical, Commercial and Art—and from trade associations and professional institutions. The Institution of Production Engineers is represented on the Advisory Committee for Engineering by Mr. J. F. Gibbons, M.I.Prod.E.

It will be understood that space does not permit of mention of more than two typical examples of the way in which provision for education and training in Production Engineering is being made in the Northern Region, but similar development is occurring in other centres of the Region which, in addition to the University of Durham, includes the Technical Colleges at Ashington, Carlisle, Darlington, Gateshead, Middlesbrough, Newcastle, South Shields, Stockton, Sunderland, West Hartlepool and Workington.

The Technical College at Gateshead under the direction of Principal J. S. Elliott, President of the North-Eastern Section of the Institution, has been active on a regional basis in providing courses in Production Engineering. Higher National Certificate Courses in Production Engineering, which have nationally expanded rapidly over the last four years, are offered as part-time day and evening courses, and are supported by well equipped Machine

Tool and Metrology Laboratories. Much more use of the facilities, particularly the part-time day courses, could be made by industry of the area.

A More Scientific Approach

It should be realised that these courses are not the same as the older type of Workshop Engineering courses, but embrace much more science, and approach the problems with a high degree of analysis. They are, in their sphere, equivalent to the well recognised courses leading to Higher National Certificates in Mechanical and Electrical Engineering. The subjects studied include Production Processes, Machine Tools, Metrology, Jig and Tool Design, and at the post-certificate stage, subjects concerning Production Management. These studies, combined with practical training and experience in the factory, provide a balanced training for those destined for responsibilities for production.

At King's College, Newcastle-on-Tyne, there have been two major developments in the Department of Mechanical and Marine Engineering, under the direction of Professor A. F. Burstall. The Degree Course in Mechanical Engineering has been re-designed in the final year to provide, in addition to the normal Mechanical Engineering course, a parallel course which has a considerable Production Engineering bias. A further development has been the establishment of a College Certificate Course in Production Engineering at post-graduate level.

This course has been devised to give a training suitable for students whose primary interest is in engineering manufacture, and extends full-time from October to June. It is open to graduates in Applied Science and to holders of a Higher National Certificate in Engineering.

At King's College, the subjects are Production Processes, Jig and Tool Design, Engineering Administration, Metallurgy, Industrial Health and Statistics.

Both the University and the Technical Colleges of the area offer extensive laboratory facilities and the teaching staffs include members of the Institution who have, through the Section, particular opportunities for close contact with industry.

Sir Ewart Smith, in his paper to the British Association in 1950, directed attention to the urgent need for a substantial increase in the number of technologists entering industry each year.

Those responsible for the provision of education and training facilities in Production Engineering have been alive to the need and have been bold in their development work.

It is, therefore, in the national interest, as well as their own, for the Directors of all organisations to review their schemes to make

sure that they are using the facilities to the full in providing, not only a stream of well trained designers but also a stream of able men who have, through specialised study, fitted themselves to contribute effectively to the promotion of efficient production and whose training and education makes them worthy of consideration for senior positions in Production Management.

COSTS AND COSTING FOR THE SMALL FIRM

by R. W. MANN, M.I.E.E., M.I.Prod.E , M.I.Min.E.*

AFTER considerable experience of costing for both small and large firms, I have a full sense of the risk involved in offering an outline of general procedure, and if the reader will realise that a costing system must be " tailored " to suit the user, accepting the fundamentals as a guide, then perhaps the risk will not prove too great.

Firstly, at what stage does a firm require modern costing? It would be easy to say that every firm requires modern costing, but out of my experience I know that it is not essential to the very small firm, i.e. the firm comprising the employer, and perhaps half-a-dozen or so workpeople.

Usually this kind of firm makes specialist requirements for other people, with whom a mutually satisfactory price can be agreed. Alternatively, the good commonsense of the average engineer will enable him to arrive at a reasonable price, probably one that it will fetch in the open market.

Where this rule of thumb method does not appeal, then the simplest form of cost deduction can be applied. Generally, the easiest way of applying such a method of cost deduction is to calculate the total working hours in any one year, and reduce this to 60 per cent. to provide a reasonable margin. From this point, a calculation should be made of the total cost of running the business, excluding production labour and material. By dividing this total expense by the number of hours arrived at as above, one has an hourly oncost.

If, now, each separate job is priced for labour and material and oncost charged at the above rate on the time required, this will give a reasonable works cost to which should be added a percentage for profit, thus arriving at a selling price.

You will note that I have used the term " cost deduction " ; this is a method for arriving at a selling price which has no relation to modern costing whatsoever, but is a basic fundamental which the small employer must have to exist. We have now to consider at what stage, and to what extent, a system of modern costing is essential to the profitable production of engineering products and I would like to use a simple analogy.

The beginning of costing as outlined above, is like the milk teeth of a child, which serve their purpose so long as the child is

* See page 536.

small. As the child grows to maturity, the milk teeth fall out and are replaced by a set of permanent teeth ; it is at the finish of the milk teeth stage that an engineering firm needs a permanent costing system.

Just as the set of adult teeth is meant to last for a lifetime, the costing system should be such that it can develop step by step, serving the interests of the firm irrespective of the size to which it may grow, without any radical alteration.

My purpose here is to outline a costing system, not too complicated for the small firm, that can grow into the permanent system of the factory.

The main purpose of the above analogy is to underline the necessity that once the milk teeth stage is finished with, a costing system that will last should be adopted, irrespective of its apparent complication. From this it follows that during the milk teeth stage, the requirements of a modern costing system should be understood and preparation made for the inevitable stage of a proper costing system. That is, if it is the intention of the employer that his firm should not remain a one-man concern, but should grow in importance to himself, his workpeople and the nation as a whole.

Costing for the 'Not-So-Small' Firm

Firstly, we have to recognise the purpose for which we require costing. Costing is not for the purpose of arriving at a selling price, which generally is fixed on the economic law of ' Supply and Demand.'

Its ultimate purpose is to provide the lowest possible factory cost for an article of a given quality, so as to leave the maximum margin of profit between factory cost and selling price.

It is essential in broad principle, therefore, that a costing system should not be a mere historic record. The historic method is to produce an article keeping careful records of the cost, so that by the time the article is finished you know what it has cost to produce.

Insofar as by the time the cost is available, the article will already have been sold at a fixed price, the use of such costs is known as ' historic ' and serves no useful purpose other than to give a certain amount of satisfaction if the historic cost shows a profit on the selling price, or an equivalent amount of misery if it shows a loss!

The real purpose of costing is to be able to arrive at the figure which the article *will* cost, not what it has cost, so that the profit or loss can be recognised before the contract is undertaken, not after. Further, by providing simple methods of analysis of costs, indication is available where improvements can be made in the cost of production and rate of productivity.

Such a method is known as Standard Costing. Here each article or operation is produced against what it should have cost, and it is

the comparison between the price which it should have cost and the price which it did cost, which opens the doors of complete cost analysis upon which successful businesses, private fortunes, and happy human relationships coupled with high wages for employees are built.

Stages to a Standard Costing System

Identification While with the smallest and the not-so-small firms, it is perhaps not absolutely essential for every article produced to be known by a number rather than a title, it is an absolute " must " if the firm is to grow to an appreciable size.

It is recommended that a study should be made of the American system (already 45 years old) of Styles, Sub-Styles and Item numbers.

Use of such a system simplifies publicity, correspondence, invoicing, progressing, production and all the other essentials of business, in addition to the simplification required for costing itself.

Drawings and Modifications From the point of view of future cost analysis, production should operate under a satisfactory drawing office system. Any given drawing number must for all time represent only those things shown on that drawing, any modifications made being shown by additional sub numbers on the drawing and all such changes recorded.

Without these precautions confusion is bound to arise as to the specific work carried out on an article.

What is Cost? The ultimate cost we are seeking will be inclusive of the entire expenses of production and distribution, i.e. the selling cost exclusive of profit.

Without going into precise details it is sufficient to say that unless all the articles manufactured by the Company contain roughly about the same proportion of Material to Labour, then it is essential to have this main cost split, and the system described herein is based on that procedure.

Firstly, the factory cost, i.e. the cost of the article in labour, material and on-cost attributable to the factory ; secondly, this factory cost increased to the total cost by the addition of a commercial on-cost i.e. all those things attributable to the commercial handling and sale of the article.

Factory Cost

The factory cost, which will become the standard cost, is the one on which future engineering analysis will be based and comprises in detail :

Labour

Obviously of course we are talking of productive labour and nothing comes under the charge of labour which is by way of supervision, but in spite of this, the cost of productive labour is capable of a number of interpretations.

It should be made clear at this point that the descriptions concerning productive wages in this article, are associated only with piece-work in one form or another.

Historic costing of a kind can be carried out where ' time ' work is in force, but standard costs and modern cost analysis are completely useless unless worked in conjunction with a modern piece-work system. Productive labour can, therefore, include the amount of basic wages paid to an operator for the actual time in carrying out the job, it could include the bonus earned by the operator on that particular job and overtime or night-shift bonuses, all of which are payment for productive labour.

Now the inclusion of all these variations will not only seriously complicate a costing system, but will make accurate analysis almost impossible. The only labour we are concerned with, therefore, is the basic wage paid to the operator for the time he took in carrying out the job and the disposal of the other shares of these productive wages is explained as follows.

It is quite obvious that the selling price must remain fixed for the customer over any given length of time, and it would be quite useless attempting to explain to your customer that a price must be modified because a particular operator earned more or less bonus ; a similar argument applies to both overtime and night-shift, i.e. the customer is not interested in internal variations.

Hence, these are considered as chargeable to on-cost and spread evenly over the whole of the products made by the Organisation.

Having agreed that the only figure we are immediately interested in is the amount of wages paid to the operator for the time he took to produce the job, it is now necessary to remember that there will be another labour figure to consider, i.e. the labour figure that is to be included in standard costs (the figure which it should cost).

The labour figure of actual production is straightforward, merely being the time put in by the operator on that job converted into money. The labour figure for the standard cost calculation is not quite so straightforward.

If we are going to introduce standard costing for a complete article, the first procedure is to split it down into its component

parts, costing being carried out on each component and the total of the components added together later to form the cost of the complete article.

Somebody at some stage has to decide the way in which each component is going to be made and it is just as easy to decide that issue before the material reaches the Shops, as it is to find out after the article has been made.

The first step is to decide how a component is to be produced, e.g. a particular component may require turning, milling and grinding. The next step is to decide, as part of the system of rate fixing, how long a normal type of operator would take to complete each operation and add to this the amount necessary for a diligent operator to earn a bonus.

On the assumption that 50 per cent. is satisfactory, if the time estimated for the operation is 8 minutes, the time allowed will be 12 minutes, *but* the labour cost included for standard costing is based on the nett time, i.e. 8 minutes multiplied by the basic hourly rate of that operator.

(The ethics of rate fixing to form the basis of a satisfactory piece-work system to both employer and employee, are dealt with in separate publications).

We have now got our standard labour cost to compare with the actual costs recorded during manufacture, providing the basis of cost analysis, which will be discussed in detail later.

A note here with regard to the labour rate is of interest ; it may be that out of a small battery of millers, one machine may be operated by a man, another machine by an improver and a third machine by a woman operator, in such circumstances the average rate per hour is used.

Material

For generally similar reasons to those given in connection with bonuses, the material included in the standard cost is the material which should be used in the production of the article.

If for instance the particular article required 4 inches of 1 inch diameter bright steel bar, then the value of that material and that value only should be included in the standard cost.

It might well be that during the course of operation the 4 inches of steel is scrapped and the Works draw from Stores a further 4 inches of material.

It should be so arranged in the Works system that replacement of scrap material can only be issued on a special requisition, and the cost of that material charged to on-cost.

Under this method, costing of material becomes very simple indeed : it is only necessary to value, from a schedule of material prices, the material called for on the drawing.

On-Cost We have already explained the necessity of dividing the on-cost into two sections. Some will, without question belong to the factory and others without question belong to the Office, whilst a number require a reasonable division of allocation.

In the complete sample system following later, all such costs have been arbitrarily divided and it will be necessary for each individual factory to make allocations suit their own particular purpose.

It is, therefore, assumed at this point that the total factory on-cost has been ascertained in the terms of an annual figure, i.e. it might well be based on the last year's profit and loss account.

It is now necessary to decide the basis on which this on-cost is to be charged.

Firstly, it has to be recognised that this on-cost must be in relation to labour only, unless all material used is identical. For example, if on-costs were spread over labour and material, one article made of gold might take exactly the same time as a second article made of cast iron, but would recover much more on-cost, yet the time spent in the factory is the same.

Secondly, it must be remembered that on-cost recovery should not be based on a fully employed factory. A reasonable figure would be 70/80 per cent. full. The basis then would be this percentage of a full year's nett wages of productive workers.

If, for instance, the total wages so compiled, amount to £1,000 per annum and the on-costs compiled as above amount to £1,500 per annum, then factory on-cost becomes 150 per cent. based on labour.

It will be appreciated, however, that if the costing system is used satisfactorily to increase productivity, then the wages bill for a given output will come down but the total on-costs may go up—not necessarily in the same proportion. It would, therefore, appear necessary to have the on-costs calculated each year ; this however is not desirable.

The whole basis of standard costing is comparison and it is essential to carry this beyond one year. The factory on-cost should be allowed to stand for five years, and while the yearly figures may be taken out, any variation which exists between them should be adjusted in the ratio of profit factors, rather than in the costing factors.

Over a period of 20 years standard costing, a factory may find its on-cost changing from 80 per cent. perhaps up to 200 per cent. and during this period a change should be made every five years. After this time the ratios may well be satisfactory for all time.

Having made reference to a wide divergence of on-cost percentages, it must be made clear that these figures have no bearing

whatever on the overall efficiency of a factory. A factory with 150 per cent. on-cost may have achieved it as a result of increase of productivity, or may have achieved it by gross inefficiency.

Summation of Factory Cost

With the three constituents of factory cost now obtained, the standard factory cost of any article now becomes nett labour, plus on-cost percentage plus material, i.e. factory cost.

Commercial Cost

To this factory cost it is necessary to add a commercial cost to cover the whole of the outlay involved.

This time, the recovery of the commercial on-cost is not in relation to labour but in relation to factory cost, since commercial expenses, discounts, etc., normally vary with selling price, which is of course influenced by both labour and material content.

Assuming the total commercial cost for a year's working has been ascertained as in the case of the factory on-costs, it is then possible to set this against the total factory cost, using labour and on-cost extracted for the factory on-cost calculation plus the material ordered for the previous year's production.

That is to say, if the total factory cost for the year was £5,000 and the total commercial cost £2,500, the ratio would be 50 per cent. i.e. the factory cost for any article would have added to it 50 per cent. for the article to recover its share of the commercial on-cost.

While the above may seem on the face of it complicated, it is in fact not really so, and once the standard costs have been obtained for each article, then the factory cost, the addition of the commercial factor and the addition of profit to give a selling price is simple and straightforward.

The Costing System in Actual Practice

It will be appreciated that to build up such costs, and have them available for works comparison, involves a certain amount of paper work and in order to make the whole procedure clear and to offer as a suggestion certain types of paper work which will fulfil requirements, there follows now the building up of a complete standard cost on a specific article for a factory employing, say, 50/60 people.

Practical Example of Establishing a Standard Cost

The Article

It is assumed that the article to be produced is a handle comprising two parts assembled together, known under the adopted system of numerical notation as Style No. 1, comprising two items, namely : No. 100 and No. 101 respectively.

The drawing showing the complete assembly is No. B.1006 and the drawings showing the items are : D.1500 for Item 100 and D.1501 for Item 101.

In a properly organised system, the whole of the above information will be recorded in an Item/Style cross-reference book.

Drawing D.1500 shows that Item 100 is a casting, which is bought in at a price of 1s. 6d. and has to be machined.

Drawing D.1501 shows that Item 101 is a lever which is produced from 4 inches of 1-inch diameter Bright Mild Steel which is bought in as raw material at a price of 2d.; this also has to be machined.

Drawing No. B.1006 showing the assembly, indicates that the two items have to be joined together by riveting, thereafter the article is to be painted and delivered to Stores. The procedure now becomes as follows.

The first stage is deciding upon the machines on which it is to be produced, and the allocation of times to the operators which will allow them, on average, to earn 50 per cent. bonus.

A Sample Job Card (Fig. 1) shows this decision completed for Item 100.

MASTER JOB CARD

W.O. No.	
PRIORITY No.	
ITEM/~~STYLE No.~~	100
No. OFF	
DRAWING No.	D.1500
COMPLETED BIN No.	
DATE OF ISSUE	

DESCRIPTION

HANDLE GRIP

	FOUNDRY			MACHINE SHOP			ASSEMBLY SHOP			
	£	s	d	£	s	d	£	s	d	
						9·4				

DETAILS OF OPERATIONS	JIGS	GAUGES	TIME ALLOWED	LOCATION	OPERATION
Face, drill, ream, turn and chamfer			Mins 15	C/C	1
Face to length, turn, chamfer second end			9	C/C	2
Drill three .25" diameter holes	K1233		3	D/R	3
Inspect.					

FIG. 1

The times allowed to the operator have been converted back into money to represent the nett time involved in doing the operation at the basic consolidated rate paid to the operator, as follows.

The time allowed to the operator for Operation No. 1 is 15 mins., which includes 50 per cent. bonus. He should complete this operation in 10 mins. and at a Capstan Operator's rate of 2s. 7¾d. per hour, this equals 5.25d.

Similar calculations in respect of Operations 2 and 3 give a total of 9.4 pence, being the total nett labour which should be expended to produce the article, and this is shown as the standard labour cost on the card.

Similar cards would be prepared for Item 101 and the Style No. 1.

Material

The material cost of the casting, Item 100 which is being bought in, has already been given as 1s. 6d, while the material for Item 101 bought in as raw material, has already been given as 2d., while for the rivets included it is assumed the cost is .03d.

Factory On-Cost

In calculating the factory on-cost, as previously described, let us assume the items of on-cost are as follows :—

Electricity	£300
Gas	650
Rates and Water	100
Sundries	300
Repairs and Renewals	600
Printing and Stationery	200
Salaries	700
Telephone	50
Cleaning	150
Insurance	50
Depreciation	600
Consumable Stores	1,000
Service Wages	1,400
Standing Time	100
Holiday Credits	400
Holiday Pay	200
Bonus	4,500
Overtime	300
Rectification	200
N.H. Insurance	500
Scrapped Material	150
Travelling Expenses	50
	£12,500

The above shows that the on-costs total £12,500.

If this factory has 20 skilled men, 10 male machine hands and 10 female machine operators, on working out the total nett consolidated wages for the year, it will be found to be £9,082 0s. 10d. As previously indicated, it is necessary to assume that the factory may not always be fully occupied, and the on-cost will, therefore, be spread over 70 per cent of this labour, i.e. £6,357.

As the labour cost is £6,357 and the Works on-cost is £12,500 the factory on-cost percentage is 196.6 per cent. (for practical purposes assume factory on-cost as 200 per cent.).

We are now able to build up the complete factory cost of the article Style No. 1.

Standard Factory Cost

It is necessary to have some form of records for the various Items and Styles, on which labour, material and on-cost can be entered and also Works costs recorded for use at a later date for standard cost analysis.

~~STYLE~~ ITEM 100	TITLE. Handle Grip
DRAWING N° D1500	MATERIAL. Casting (Purchase)

FACTORY COST	COMMERCIAL COST (F.C. PLUS 25%)	PROFIT FACTOR	SELLING PRICE	DATE
3/10·22	4/9·75	·85	5/8d	16/4/53

DATE	12/12/51		INSPECTION	4675	5972	7111
FOUNDRY			ORDER	5492/1	6731/1	7962/1
MACHINE SHOP	9·4		MONTH	7/52	10/52	1/53
ASSEMBLY SHOP			F.			
TOTAL	9·4		M.	8·62	9·2	8·9
ON COST	1 6·8		A.			
MATERIAL	1 6		% PASSED	95	97	97
TOTAL FACTORY COST	3 10·2		STANDING TIME.	1 hr	30 m	1 hr

FIG. 2

Fig. 2 therefore shows on a standard record card, the completed factory cost for Item 100. Similar cards would exist for Item 101 and the complete Style No. 1.

It must be appreciated that there is provision on this card for further figures which will be added later.

Commercial Cost In order to arrive at the total commercial cost, we have to establish a ratio between factory cost and the total outlay required commercially to run the factory.

Assume here that such outlay is :—

Electricity	£50
Gas	100
Rates and Water	50
Sundries	200
Repairs and Renewals	300
Printing and Stationery	500
Salaries	3,500
Telephone	200
Cleaning	150
Insurance	20
Depreciation	150
Carriage	900
Publicity	3,000
Postage	250
Bank Charges	100
Travelling Expenses	400
Audit	100
N. H. Insurance	220
	£10,190

The total commercial cost then is £10,190.

In order to obtain the required factor, we have to ascertain the total factory cost of the factory. Labour and on-cost we already know. Reference to last year's accounts shows the total amount of material purchased as £26,000, and if the factory is to produce at the same rate, this figure can be used for the current year.

The total factory cost now reads :—

Labour	£6,357
Material	26,000
Factory on-cost	12,500
Total Annual Factory Cost	£44,857

To recover the commercial charges of £10,190 we must add 22.71 per cent. to this figure (for practical purposes use 25 per cent.) and this becomes our commercial on-cost.

Reference should now be made to Fig. 2 where it will be found that the factory cost has been carried upwards, and 25 per cent. added to give the commercial cost.

This figure has been divided by .85 to give a selling price, with a 15 per cent. profit.

For the complete Style the factory costs of Items 100 and 101 are added to the cost of rivets, to give the total material content of the Style. The addition of assembly labour plus on-cost then gives the total factory cost of the Style. This factory cost can then be increased to commercial cost and selling price as above.

Completion of Record Cards by addition of Actual Manufacturing Costs

It is not within the scope of this article to deal with production systems, time recording and labour costing, but they must, for the purpose of cost analysis, comply with certain conditions.

With standard costs it is unnecessary for shop costing of material. The actual labour costs must, however, be extracted in three separate sections.

(1) The cost of completing the job at the consolidated basic wage.

(2) The amount of bonus earned.

(3) The amount of money paid in respect of overtime or night-shift premiums.

The above figures will of course provide the whole of the information necessary for the Cost Department to build up Works wages and payments.

In addition to the above, the labour costing system should record :—

(1) The amount of standing time, i.e. the 'unproductive' time which has to be paid for at consolidated basic rates.

(2) The numbers failing to pass the Inspection Department.

In connection with (2) the Inspection Report should show the actual operation on which the fault has occurred. On completion it will go to the Cost Department indicating the closure of the job, and that Department will then have the required information.

Fig. 3 shows both sides of a typical inspection card covering Item 100.

The Labour Cost Department will provide at the end of each month a schedule showing the entire output of the factory for that month, with all the required information thereon, together with the summation of the month's output.

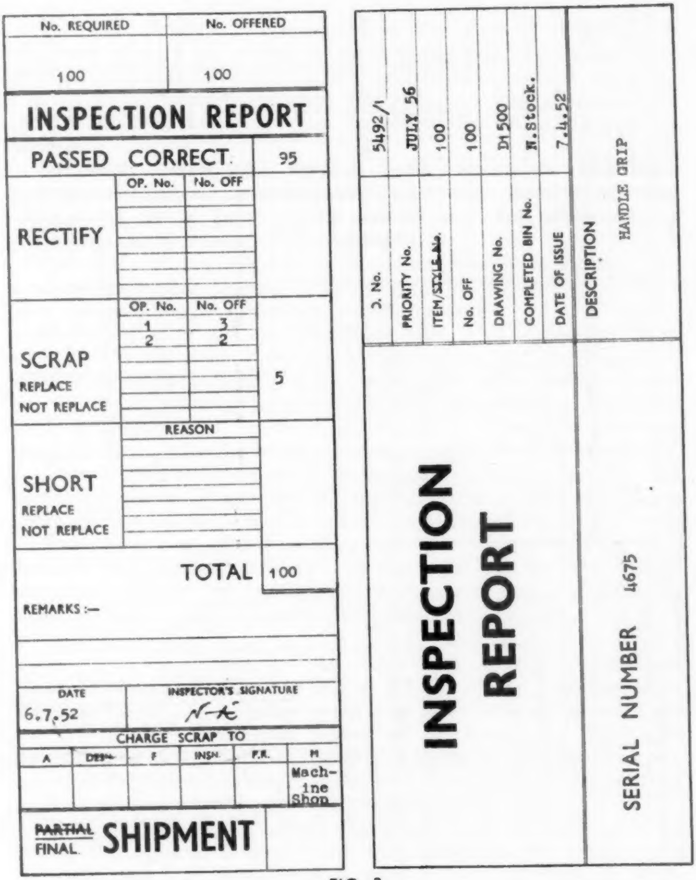

FIG. 3

Fig. 4 shows a typical monthly analysis sheet and this, together with our record cards, provides the basis for the cost analysis for which we have been working.

Cost Analysis Department

From the analysis sheet details of the average labour cost, standing time, scrap, are entered on the record cards, and it is from these that cost analysis can commence.

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WORKS MONTHLY ANALYSIS Month ending 31st July, 1952 Sheet No. 20.

Inspn. Card No.	Job No.	Item No.	Section	No. Called For	Inspection Report: Passed	Rectify	Scrap	Shortage	Cost Allowed	Cost Incurred	Bonus Paid	Rectifn. Costs	Works Units of Scrap	Charge to	Standing Hours
	CARRIED FORWARD								6214 16 11	5873 14 1	3563 11 7	40 1 3	110 7 4		127
4675	5492/1	100	M	100	95		5		3 18 4	3 8 3	2 4 3	- - -	3 11	M	1
4677	6223/1	86/L.21	M	750	742	5	3		22 8 7	19 6 3	11 4 1		1 10	M	
4678	7251/2	JD.1532	F	500	500				6 15 5	5 6 11	3 2 6				
4679	52241/1	1402	A	6	6				4 0	4 0	2				
4680	55208	Drill 5976	A	1	1				1 7 10	19 6	13 11				
4681	7464/1	D.1632	M	100	95	5			13 16 6	10 11 8	6 18 8				
4682	7987/1	237/P.152	M	135	135				16 11	10 9	8 6				
4683	8006/1	M.761	M	208	203		5		8 0 9	7 15 6	4 - 3		3 11	M	1.30
4684	8121/1	P.304	M	200	200				16 19 2	14 15 -	8 9 7				
4685	8232/1	92/F.612	A	12	12				6 -	3 -	3 -				
4686	8296/2	JL.284	F	40	40				3 3 4	2 16 -	1 11 8				
4687	6223/1	86/L.21	M	5	5				3 -	(See Inspection No.4677)		7			
4688	8356/1	624	M A	100	103				6 5 19 4	6 - 16 8	3 2 9 8				
4689	8462/1	E.27	M	120	120				1 11 3	1 12 5	- 14 5				
4690	8473/1	D.127	M	250	247		3		6 8 7	3 4 9	3 4 3		1 7	M	
4691	58996	Drill 3081	M A	1	1				1 11 1 3 1	1 4 19 11	11 11 7				
4692	7464/1	D.1632	M	5	5				14 2	(See Inspection No.4681)		5 0			
4693	8509/2	J.D.326	F	125	125				18 17 7	13 7 3	9 8 9				
		TOTAL							6322 19 1	5959 19 3	3617 2 9	40 6 10	110 18 7		129.30

Form No. 305

FIG 4

The Cost Analysis Department, or the Record Department, whatever it may be called, is the central hub of any factory's productivity, and it must be clearly understood that if at this stage the figures are simply recorded and left, then the whole costing system becomes no better than an historical cost, and serves no purpose.

Correctly used, the figures now available can add systematically to productivity and the profits of the Company, at a rate which could not be achieved by doubling the number of workpeople.

The basis of cost analysis is not examination of figures, but comparison, and there must be two or more Works costs on a record card before it begins to serve any useful purpose.

From Fig. 2 it will be seen that there is provision for three recorded Works costs ; the card then becoming complete it is submitted for cost analysis by the responsible individual appointed for the task, preferably a committee of responsible people which could well comprise the Works Director or Managing Director, the individual responsible for the system, and the Chief Engineer.

Three Works costs are available, because of the probability that the three jobs will have been done by different people, and one or more at least will represent a reasonable effort on somebody's part to earn a bonus. Further if a cost has been "faked," it is unlikely to have been "faked" in the same way on three widely separate occasions by possibly more than one person, having in mind the large number of jobs going through the factory.

Cost Analysis of Record Card

Let us now turn back to the record card (Fig. 2) which has on it the standard cost, together with the data derived from three separate times of manufacture. We must remember at this point that the card is probably up to a year old, and that the people looking at it will have a further year's experience in the utilisation of old and new machine tools.

The first thing is to compare the actual costs obtained with the standard cost, and it is obvious that, although the record card for Item 100 has been filled in with a specific result, a whole variety of results could have been achieved and it is in this general sense that the comparison is now discussed.

It must be understood that the standard cost is equal to the Works cost only if the operator earned exactly 50 per cent. bonus. If the Works cost is lower than the standard cost, then the operator will have earned more bonus than 50 per cent. One or two o the workers may have earned excessive bonus, where the other has not. Under these circumstances, it is a reasonable differentiation between the man who is working all out and the man who is not.

Assuming the lower price is round the standard cost the price to the Works can be left as it is, bearing in mind that a second thought will be taken on the same point approximately one year ahead.

On the other hand it may be that all three operators have earned excessive bonuses ; in this case it is probable that the standard cost is too high. Examination of the operation cards for this particular job, will indicate where the mistake has occurred. It is unlikely that all operations are excessive, and the mistake has probably occurred on one or two operations only.

Under a satisfactory piece-work bargain with the workers, a correction to the time for the excessive operations should be made and the standard Works cost altered accordingly.

If all three Works costs are consistently higher, then it is an indication that the standard cost is too low and that the bargain between Management and Workpeople has not been kept. The times allowed should be increased, raising the standard cost and the money which would have been earned had the corrected rate been operating when the three jobs under review were done, paid to the operators.

On the other hand if the prices are all consistently high, and at the same time the number passing Inspection is consistently low, then the high prices have been caused by failures which may be, or may not be the responsibility of the workpeople ; this issue is dealt with later.

It may be that two of the prices are satisfactory and the third price high, indicating that two of the operators are capable of an average performance and the third operator is not.

In the small factory, repetition of failures of this kind attributable to an individual will soon serve to indicate who are the best men and who are the poorest within the Shop, with obvious possibilities.

The main advantage of the comparison so far, has been to ensure that the manufacture of a complete article does not look satisfactory on the basis of too good a price on one operation, and too poor a price on another ; it has the advantage that it is bringing the standard prices in line with productive prices nearer and nearer year by year, so that no single operation in the factory is carried out at a loss.

Last but not least, it has the moral advantage of being able to deal with production on a scientific basis instead of ' rule of thumb ' or guess-work methods.

The next issue lies with the percentage Passed Inspection column. Here nothing could be more desirable than that each of the three Works records show 100 per cent. Passed Inspection. If they have all ultimately passed through Inspection at the expense of rectification, that fact will already have become ascertainable

out of the comparison of standard cost figures. The value of this column, however, arises when all the articles do not pass 100 per cent. Inspection.

Here again a whole variety of figures can be provided and the possibilities studied in that light. If, for instance, two of the columns show 100 per cent. Inspection and one column shows 50 per cent. Inspection, then in the sense that a further opportunity will be given when the card is seen next year, it would be reasonable to assume that a mistake has been made in the Shop (which of course is inevitable at some time) and there is nothing wrong with the manufacturing procedure.

If, on the other hand, the figures were to show a consistent 70 per cent. through Inspection, then analysis is required.

The detailed inspection cards of these three jobs are now called for and, in general, it will be found that one, and at most two, of the operations out of the series are responsible for the scrappage.

Men on piece-work do not scrap production for fun, insofar as they are only paid for that which passes Inspection. Once the operation on which the scrappage is effected is known, reference to the drawing, or the manufacturing instructions, will almost certainly indicate the cause.

Under these circumstances the Chief Engineer is brought into the picture with a Works request that the design or dimension be modified. If this cannot be done, then the Works have to face their own problem either by the design of special jigs and tools for that particular operation, or the stipulation of a special type of tool. In either case the future scrappage due to this difficulty is avoided. It is impossible to overstress the importance of this particular piece of analysis.

Standing Time Figures

The next step in analysis is in reference to the standing time figures ; variations in the standing time taken per job are often an indication of the various skills of the tool-setters, and where time and opportunity serve, the comparisons could be made to pick out the good tool-setter from the bad, again with obvious implications.

More useful, however, is the possibility of comparing the time taken to set up a machine in relation to the time taken to complete the work. Where this time is excessive two obvious alternatives are available. One, that in association with the commercial departments the number required at any one time might well be increased, even if it means carrying a little larger stock. Alternatively, there is the desirability of designing a complete kit of tools for the particular operation which could be drawn with the material.

It will be understood that in the description of this analysis one has only really outlined the possibilities of a three spot comparison, and to the engineer with ingenuity all sorts of combinations can be used almost to write a story of the production of that particular product.

Now finally from the record card, with all the above features dealt with, one comes to perhaps the most important point.

Here, at no longer period than once a year, and completely automatically, is brought to the attention of responsible people, the results of manufacture of every article made by the Company, one by one. Not only has systematic costing analysis ironed out the divergencies of present practice, but it provides an opportunity for the people concerned, and with the particular job fresh in their minds, to consider the whole of the original job cost in the light of their present experience.

The job card may call for the job to be done on a lathe because at the time the job card was made, there was no capstan of the size required available, but today—a year later—that capstan is installed in the Shops and the job card can be re-written for a completely different process of manufacture, resulting in the reduction of manufacturing costs.

Alternatively, it may be recognised that the complete item can be purchased into the factory at a lower price than the factory cost, and provided that the factory is not short of work, it will be more economic to purchase outside.

Alternatively again, it may be that an item produced from a casting is now in the light of present knowledge, capable of being produced from a hot brass pressing or a stamping, with very considerable overall economies to machining time. These and a hundred other alternatives will come automatically to the mind of the Production Engineer who is striving in his professional capacity for productivity.

Managerial Analysis

For the purpose of our article the story is now complete. By and large the backbone of standard works costing has been examined, but it will be appreciated that in actual practice additions are made to suit each particular factory; then it might well be for instance the record card will be used for the referencing of order levels, method of stocking, cross references with catalogues and many other things than have been indicated on the simple illustrations used.

To end the story where we started it, from the backbone must be built the system to suit the particular Works. Nevertheless, there are certain advantages which come to Management quite

outside the ordinary procedure of costing and costing analysis as outlined above, which it is felt should be touched upon for the benefit of those who wish to think a little further ahead.

Insofar as the standard cost values are the nett manufacturing time, it must be clear that the productive wages paid in any week must immediately be a measure of the possible output from the factory. This can be used not only for the purpose of targets, but for the analysis of machine battery capacities, and there from the complete progressing of material through the Shops.

For example, a battery of capstans has a total of basic consolidated wages amounting to £30 0s. 0d. per week; then that battery can only deal with jobs coming into the factory with standard works costs attributable to capstans (as per the job cards) to the amount of £30 0s. 0d. per week.

If more work is coming in, the capstan battery will be overloaded, and if less work is coming in the capstan battery will at some time run out of work. Transferring this possibility to actual managerial activity, one could suppose the following.

A new design has been produced, and the Sales Manager informs Management that with the necessary sales organisation he can sell one thousand articles per annum. Supposing Management agree, then the Sales Manager is free to set to work to engage his sales staff to sell a thousand articles. From the job cards and the standard works cost, the total amount in £'s of the labour required per machine battery to produce a thousand, is a matter of a moment's calculation.

Going back to our capstan battery which was capable of £30 worth of work a week, but is actually only doing £25 worth a week, it is seen that with these new thousand articles £10 worth of additional capstan work a week will have to be produced.

The Works Manager is immediately in the position to say that if these thousand articles have to be made, then one more capstan will be required and so on throughout the whole of the range of machines within the factory, so that on the same date on which Management make a decision to produce and sell an article, the actual machine tools can be purchased and by the time that the materials arrive and the jigs and tools are complete, the machines should be available in time to meet the selling programme of Sales Management. This is but a typical example.

Each month from the Works monthly analysis, as in Fig. 4, there is added the total number of standard cost £'s of output which immediately give rise to a comparison month by month of Works output, showing Management the extent to which it is going up or down and capable of comparison with either the budget for the sales, or the actual sales coming in month by month to the factory.

Similarly, the total amount of the monthly bonus can be ascertained for comparison with the previous month. There is no better guide to Management than to have adequate assurance that bonus payments remain either static or slightly rising. There is no more clear indication of future danger and loss of Employer/Employee relations where the bonus is being steadily reduced or widely fluctuating.

In the same way, overtime premiums could be compared with previous months to see whether overtime is being worked or not in the Shops, and what is more important, whether it is being overworked. There is nothing more certain than that consistent overtime does not pay.

Again, an examination of total standing time for the factory is a clear indication to Management as to the continued efficiency or otherwise of their tool-setting staff, and finally of the value of the transfers of scrap and rectification to on-cost, a sure guide to the way in which things are going.

In conclusion, the Writer trusts that sufficient has been said to convince the reader that scientific management is not only interesting, but an exceedingly profitable hobby.

SCIENCE AND THE PRODUCTION ENGINEER

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IN discussing the relation between Science and the Production Engineer, it is advisable at first to consider our terms. Let us then discuss what is meant by *Science*, and what is meant by the *Production Engineer.*

Let us first consider the question of *Science.* By *Science* I do not mean the latest advances of, say, nuclear physics, or even the latest techniques that have been developed in the laboratories of the world to investigate various problems of fundamental and basic importance. Important though these are, and great though their influence will eventually be on industry and production, nevertheless, they are not at this stage primarily the concern of the Production Engineer.

By *Science* we mean rather the scientific *attitude* based on a sound appreciation of the *basic* ideas and laws of science. Until the turn of the century, it is perhaps true to say that engineering, in all its aspects, was an empirical—a purely practical—art ; an art only acquired by direct experience in industry, making things and producing things. Appreciation of what I am here calling the *basic ideas of science* was then far from widespread ; and, unfortunately, that view is still found today in some quarters. Technical education, whether on the industrial side or in other branches of human activity, unfortunately can be so narrow that it is often difficult to discern the scientific wood from the trees, although it should be emphasised this is not always the case. Indeed, if any proof were needed of this statement, it could be furnished by a survey of the so-called ideas of great mechanical and electrical ingenuity which are presented each year in the patent offices of the world and which claim, in some form or other, to get more energy out than is put in, flagrantly disobeying the second law of thermodynamics, i.e. the basic laws of energy. I think a great deal of effort is still being wasted in trying to get machines to work, or processes to take place, in contradiction to the laws of nature. These fallacies are not often very obvious, but one must always be on guard against attempting to do the impossible.

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Up to about 25 years ago, a large proportion of the engineering industry of this country was in the hands of men whose engineering and scientific knowledge had been limited by what they had acquired from their own personal and practical experience. They worked often unaware of the contribution which fundamental sciences like Mathematics and Physics could make to their work. In this later era, of the last 20 years or so, this view has rapidly declined, and pure physicists are now being employed by large industries for work in fields which formerly never knew a physicist. This is particularly the case, of course, in the large and important light engineering industry, which in this modern age of electronic control becomes more and more important.

Although here I am making, as it were, a plea for a wide and deep appreciation of what are known as the elementary and basic laws of science and the scientific attitude, I hope to show later on that in addition, the more erudite advances in extremely academic branches of research can affect industry in a very intimate and important way.

What is Production?

As to the term *Production Engineer*, the name implies that we are dealing with a fully-trained engineer who is concerned with production of a certain article. By *production* we mean, then, not the original research connected with the project (if such research was necessary), or the development of a original idea into a form suitable for practical application in, say, a pilot plant. We mean, rather, by *production* the vast process of conversion of raw materials into an article which is required in quantity. When we consider, for example, the production of certain types of thermionic valves used in radio and radar, before the machines and equipment are laid down for production of the finished article, we find that there is usually a vast hinterland in which scientists are carrying out experiments at a research level on such so-called academic matters as work functions, cathode surface electrical layers, and so on, matters which appear to have no connection with the Production Engineer. After the idea has been fully worked out, we have the stage in which a practical form of the idea must be developed, paying considerable attention to the cost of the materials and the conversion of those into the finished article. So it would appear at first sight that the Production Engineer is concerned only with best mechanical methods of producing a given aim, the manipulation and order and direction of the machines, with one eye on the mechanics of the project.

There is one class of experience in a very modern factory in which a Production Engineer of any type may feel that he is having direct contact with science, i.e. in the realm of automatic control.

Automatic control is being used today more and more and there are some factories in which the man power is reduced to one overseeing engineer. This is a very important modern development and it does look as if it has come to stay. The basis of automatic control can be roughly classed as that particular branch representing the fusion of academic physics and practical electrical engineering known as electronics. To the operator or Production Engineer, the automatic control presents a face of black boxes, push buttons and dial lights. We have a magnificent example of push button control on a very large scale here in Margam.

It might perhaps appear, therefore, that with automatic control (with all its black magic boxes of electronic instruments and push buttons), the Production Engineer is here faced with the necessity of acquiring a scientific background in order to utilise correctly all these advances in control technique. Such, however, is not the case. I think it is not too much to claim that almost anyone can learn to operate modern electronic equipment. Young children, hardly more than babies, have been seen to manipulate correctly the intensity and focussing controls of a modern television receiver in order to bring in a clear picture. That ability is not science, and I would stress again that the need to handle and use scientific apparatus of modern electronic control is not the reason why a scientific background is highly desirable for a modern Production Engineer.

Different Types of Production Engineer

Now the term *Production Engineer* is open to extremely wide interpretation. In fact, there are almost as many different types of Production Engineer as there are different types of factories or industries. On the one hand, we have the clear case of production where a large number of articles, all identical, are being produced, e.g. nails, electric lamps, nuts and bolts. Clearly the man in charge of the production process of these articles is an obvious and simple case of a Production Engineer. On the other hand, consider the case of one piece of machinery, e.g. a new gas turbine locomotive, or a new type of aircraft. Is the man in charge of the construction of this item a Production Engineer in the same sense as the previous case? Some may argue " no," others might say " yes, he is in charge of producing something and therefore he is a Production Engineer." But clearly the problems each has to face are very different, and the strength of his reaction to scientific ideas might tend to be different in each case.

Before we discuss it any further, there is one clear piece of common ground, i.e. they both must have a knowledge of scientific ideas and a firm grasp of the basic process.

Basic Scientific Background

Let us consider a bit further how much basic science a Production Engineer should have. He is primarily concerned with making things, and in this three factors are involved, (i) *materials* out of which the final product is made ; (ii) the *machinery* which does the making ; and (iii) the *labour* which operates the machine. I submit that a working basic knowledge and understanding of these factors is necessary for a good Production Engineer. The third factor—labour—does not enter into this discussion.

In dealing with the first, a knowledge of the *materials* used, their physical and chemical properties and their cost and scarcity value, I would submit is an essential requirement. Before one knows what one can do with the materials it is necessary to know what their basic properties are, e.g. their reaction to heat and high temperature, pressure, how well they can be worked on a lathe and so on, just to name only a few. In the heavy structural engineering industry when one is dealing with iron and steel, this requirement is quite obvious. Indeed a teaching course in strength of materials is an essential part of all the engineering courses in universities. But the scope of the materials used in industry today is extremely wide and varied, far wider than can be adequately dealt with in a college course of introduction. The Production Engineer may be faced with a range which includes thermosetting plastics used for mouldings and electrical equipment, to glass for electric lamps and other electrical discharge tubes and ceramics, which are of increasing importance, especially in the electrical engineering industry. Further, there is the extremely important question of the handling of these materials : in many processes the amount of material handled in a production is many times greater than the amount of articles finally produced. If such handling is not done efficiently, considerable waste of material and effort is caused. Efficient handling of raw materials should be based on sound scientific principles.

As well as the basic physical properties, an elementary knowledge of some of the chemical properties is now becoming essential. This necessity can be seen reflected in a typical university course of training for engineers. In many of these courses, including that of my own University, the first university year of an engineering student is not spent in the Engineering Department at all, but is devoted to Mathematics, Physics and Chemistry, albeit at an elementary level. The student here acquires a firm basic ground on which he can later erect the edifice of his engineering knowledge and experience.

Secondly we have the machines ; a Production Engineer should

know the capabilities and properties of the machines under his care, but in general this is the sort of knowledge which can be acquired by experience in a works after his early training.

Problems of the Production Engineer

Now the duties and worries of a Production Engineer are not ended when his raw materials have been provided and his machines are running smoothly. The next stage is to consider the state of the final product, e.g. is the final product exactly what was desired? Does it fit the specification aimed at? For example, if nuts and bolts are being made, do the nuts always fit the bolts? Or does one find if resistances are being made, that all the resistances have exactly the right value? If electric lamps are being made, do they burn out too quickly? If so, is this a fault which occurred during the production or was it some fault inherent in the design?

Again, having got the product, is it the best form which satisfies the market? Would, for example, a slight modification help either its selling power or the ease of its production? Indeed, these are problems which at first sight can only be solved by works experience. A fault due to the wrong quality of the raw materials or a fault due to machining, one would think at first sight, is one which can be readily rectified, and located on the strength of one's formal engineering training. After all if one has had a basic scientific background and a basic training in the knowledge and operation of machines, it should be possible to locate and indicate the remedy for those more straightforward faults. But this second class which I have just mentioned, which is concerned with the properties of the end product, appear at first sight to be outside the formal training of the engineer. Their remedies can be found, it would appear, only as a result of the fine judgment born of experience alone, and which is a quality which is not the result of a merely formal scientific training. Now it is to this aspect which I should like to draw your attention for the remainder of this address. This concerns the placing on a more scientific basis, the judgments concerning adaptability and errors and departures from specification which arise in the production process.

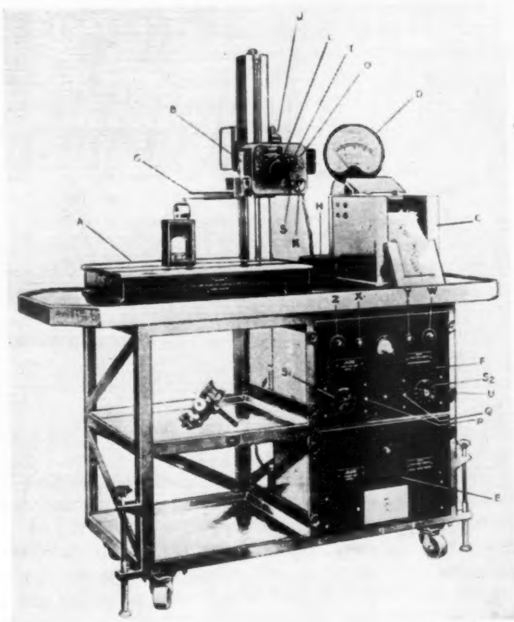
There is another important aspect of this situation which I feel can be a cause of considerable muddle, delay and waste. In a branch of the consideration of the whole process of production in which we are dependent not on a precise quantitative assessment, but rather on qualities and properties which are dependent on fine judgment based on long and particular experience, the judgment may be that of a foreman or Production Engineer or managing director. When such people have devoted a large part of their lives to a certain process and acquired in that a very high skill,

there tends to grow up as a result of that experience a kind of jargon, a new language ; terms such as ' adaptability value,' ' suitability value ' may be coined, and what they mean is known only to those who invented them. The users, i.e. the experienced people themselves, are no doubt clear in their own minds what they mean when they use such words to describe their experiences (after all *they* have had the experience) but difficulties arise in communicating these experiences to others, and sooner or later such communication must occur. When there is a question of considering policy or change of policy, discussion must occur at levels which can involve the charge hand, the foreman, the Production Engineer, and on the board the managing director. I have heard of long and intricate discussion at all levels, in which it is extremely difficult for one half of the meeting to follow or appreciate the conclusions or the arguments of the other half. An enormous amount of time is wasted in this way and with time, money and effort.

Surface Finish

Let us take just a simple example to illustrate this sort of thing. Suppose we are concerned with the *surface finish* of a product. The foreman and the Production Engineer, who may have spent many years with a certain process, when they use the terms rough, smooth or sufficiently smooth among themselves, may have a clear notion as to what that state of finish is. But those terms to anyone who has not the same specific experience with those specific materials can mean anything. Something which appears smooth to a machinist can be as rough as the Himalayas to a physicist, who is concerned with smoothness to an atomic degree. I think it is not too much to say that a great deal of confusion and difficulties has arisen through inability to specify the degree of smoothness or roughness of a surface. In the past, the assessment of surface finish imparted to a machined article has usually been a matter for the sight or sense of touch of a highly experienced foreman. As I said before, in any given factory that standard is sufficient, because the foreman probably knows every part of the process, but when we are comparing the products of one factory with those of another there can be no common ground of assessment, and this type of psychological assessment is not altogether reliable. Recent developments, however, have made it possible to assess surface finish in quite a scientific and quantitative way, in which a numerical value can be actually given to the average roughness of a surface so that a precise meaning can be given to a statement such as this surface is twice as rough as that. Here in Swansea a considerable amount of research has been devoted to this very point at the Sketty Hall Laboratory of the British Iron and Steel Research Association, where there is a " Talysurf " machine in use.

A photograph of this machine is given in Fig. 1., while Fig. 2. gives records of typical surface finishes met with in production; I am indebted to the British Iron and Steel Research Association for these.

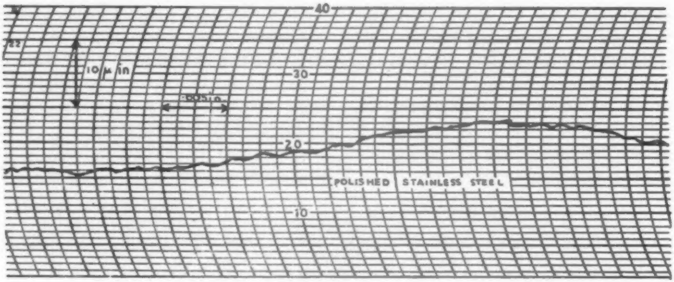


(B.I.S.R.A.)

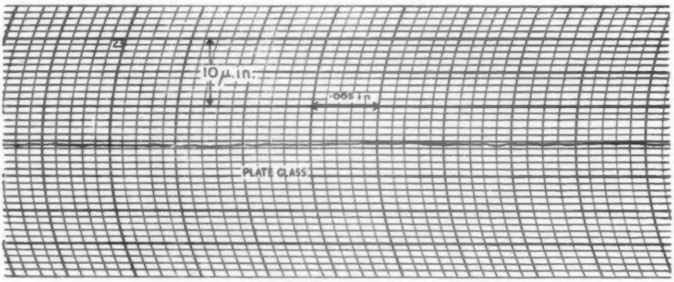
Fig. 1. "Talysurf" Machine.

Operational Research

This example which I have given is only one aspect of a very much wider problem, and it is to the developments in this wider problem I should like to devote the next few minutes. Let us consider the case of war. Prior to World War II, gun laying both on sea and on land was often the result of the fine judgment of experienced and highly trained gunners, but nevertheless it depended upon the human factor. Again, when a commander is about to carry out an attack either on fortified positions, or by landing on a beach, the type of armament used, the deployment of the forces at his command has always been carried out as the result of judgment based on long



(a)



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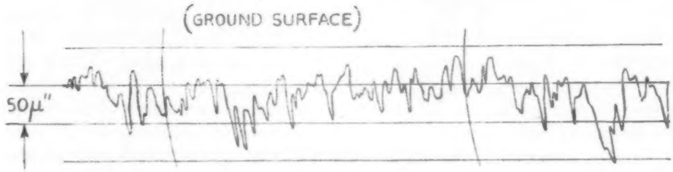

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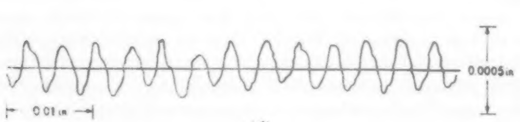


(d)

Fig. 2. (a) (b) (c) (d) Typical Surface Finishes met with in production.

experience of the commanding officer and his immediate planning staff. In other words, again it is a question oi the human factor. The history of wars since history began has shown how commanders, like everyone else, can make mistakes, and mistakes in war are costly and serious. Now, I would commend to everyone here a careful reading of the history of the actions of the Allies in World War II. I think that if he reads the official histories, together with the memoirs of the commanders and politicians, he will notice how in the early stages the actions of the Allies were characterised by calamity, lack of success, and near disaster ; while, on the other hand, the latter half of the war presented a completely different picture. Apart from local incidents and difficulties, in the main the Allies swept forward according to plan, apparently not setting a false foot forward.

One of the most crucial battles of World War II, a silent and grim and terrible battle, the battle of the Atlantic, underwent an extraordinary metamorphosis about half-way through the war. The sinkings of our merchantmen rose to alarming and horrifying heights and at one point, as in the dark days of 1917, it looked as if the British Commonwealth could not possibly survive disaster. U-boats were able to sink our ships faster than we could build them and faster than we could build and man escort vessels and aircraft to destroy marauding U-boats and hostile aircraft. The problem that faced those in control of the Allied countries was this : we had to transport essential food and raw materials across the oceans of the world in a certain limited number of ships. The enemy had bases from which aircraft and submarines could go forth to destroy the convoys. In an attempt to prevent this we had at our disposal a limited number of aircraft and surface vessels. How were we to dispose the forces at our command so as to destroy the enemy forces, when at the same time we had to use our national effort in other offensive operations and, and this is the important point, we were in complete ignorance of the exact location of the enemy forces? It is to that particular point I want to draw your attention. We did not know exactly where the enemy would be. How then was the problem met? It was met by utilising the service of physicists who were also mathematicians, and who applied mathematical theory of probability. It would be too long and difficult to explain the exact technique, but it was based on estimating the most probable position of a submarine some time after it left a known position; depth charges were then concentrated in that area. The result of this.new technique was extraordinary. The rate of U-boat killings rose, and with it the rate of merchant sinkings fell, and this was the turning point which marked the winning of the battle of the Atlantic. A man who was in the forefront of the theoretical development of this technique was the

first research student in the Physics Department of the University College of Swansea, and his death in 1945 was a sad loss to the science of the world. I refer to the late Professor E. J. Williams.

The type of application of scientific theory and conceptions to an aspect or activity which before had depended upon human fine judgment, marked the growth of a new conception in the application of science to industry and even to human activity in general. I refer to Operational Research. This perhaps fearsome title means nothing more than an attempt to do away with emotive judgments (no matter how experienced), and basing conclusions as far as possible on quantitative facts scientifically obtained. I think today industry cannot afford anywhere in the world, and least of all in this country, to ignore these new developments, and in fact the largest and most progressive organisations in this country are to the forefront in their application of these processes which have been learnt the hard way in the last war.

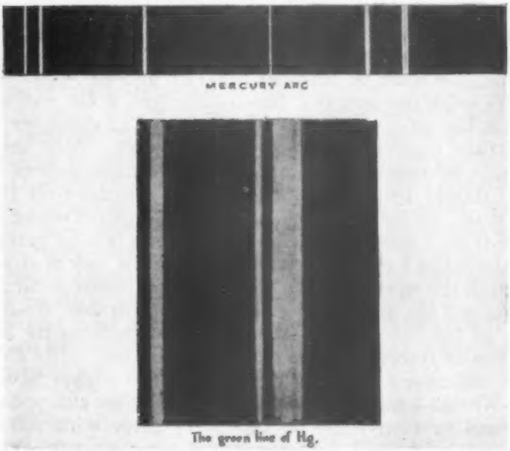
How does this affect the average Production Engineer, a man who is making nuts and bolts, or even something as simple as nails and perforated plates into which the nails should fit? No process is perfect, so that in the production of these there are bound to be departures from the maximum tolerances aimed at. Some nuts will turn out to be too large or too small for the bolts ; and some nails will not go through the holes, so a loss is entailed in trying to make other fabricated articles from these. What is to be done? Are the parts that do not fit to be thrown away? No one here will defend that procedure. It is too wasteful in materials and effort. No, one first must find how does each part of the production process contribute to these errors and lastly, but of the very greatest importance, comes the question, what proportion of the final product is outside the permitted tolerances and as a corollary to that, how are the departures from the permitted tolerances distributed? What I mean by that is, perhaps a large number are only slightly out, a smaller number may be out by a greater amount, and perhaps a smaller number are very widely out. This distribution of the errors is a matter of the very greatest importance, and this brings us to the crux of the situation.

Science and Measurement

The Production Engineer must be able to say exactly and quantitatively how much of his product has to be rejected and what is the order of magnitude of the departures from the permitted tolerances, and this brings us at once to measurement. I would submit here that no matter what type of factory is concerned, sooner or later the Production Engineer must come up against the question of measurement, and that means accurate measurement.

To fix ideas let us consider a simple example. Suppose an operator has to bore a hole nominally 1 in. in diameter, and let us suppose that the tolerance on the size of this hole is +0.005 in., that is, the hole must be between 1.000 in. and 1.005 in. In order to test this work the operator has two gauges, a Go and a Not-go gauge, the Go gauge being nominally 1 in. in diameter and the Not-go gauge nominally 1.005 in. in diameter. Now there must be a certain tolerance in the manufacture of these gauges, and this tolerance should be about a tenth of the tolerance on the work, i.e. 0.0005 in.; so that the operator has a Go gauge whose size is in the range from 1.000 in. to 1.0005 in. and the Not-go gauge whose size is in the range 1.0045 in. to 1.005 in. It is the task of an inspector to verify that the work has been done to the required accuracy. He too will have a Go and a Not-go gauge. In his case, however, the direction of the tolerances will be reversed because he must not run the risk of rejecting work that is satisfactory. His Go gauge, therefore, will have a size which is in the range 0.9995 in. to 1.0000 in. His Not-go gauge will be from 1.005 in. to 1.0055 in. Now these gauges in turn must be tested regularly with reference to other gauges which have a tolerance of about one-tenth of the gauge tolerance. We see in this way that a hierarchy of gauges is necessary, in order to ensure that comparatively crude work is done to the required accuracy. This means that there must be methods of measurement which must be sound and reliable. Now when we begin to discuss measurement to this order of accuracy, we leave the realms of mechanical engineering and enter the realms of physics.

It is necessary that a number of sets of what are known as Johanssen gauges, each consisting of 81 steel slips, should exist in the country in various factories and these gauges must be measured to an accuracy of one millionth of an inch. Measuring to this accuracy requires use of light waves, and the process of making use of light waves for measuring in this way is a well-known branch of physics known as Interferometry. Interferometry involves the use of light waves of known wavelength, and the whole problem of the emission of light by elements is one of atomic physics and of atomic structure. It is well-known that most elements can be made to emit light waves having certain characteristic wavelengths (Fig 3). It is very important from the point of view of measurement that we should choose an element which emits light of a particular wavelength without very much spread about the nominal value of this wavelength. In other words, we must make use of a homogeneous or pure spectrum line. The standard spectrum line upon which measurement has been based hitherto is the red line of cadmium. Although legally every length that is measured is measured in terms of the Standard Yard, which is kept at the Board of Trade,



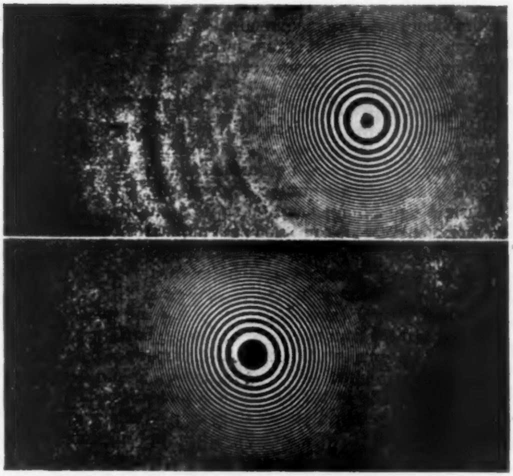
From "Treatise on Light" by R. A. Houstoun.
(Courtesy of the publishers—Longman, Green & Co., April, 1946)

Fig. 3. (above) Spectrum of Mercury Arc. (below) The Green Line of Mercury highly magnified, with good dispersion, illustrating fine structure of Line—i.e. it consists of a number of lines of different wavelength close together.

or the Standard Metre, which is kept in Paris, in actual fact as far as industry is concerned the real standard of length is the *wavelength* of the red cadmium line.

There is no point here in describing the details of the technique by which every length is measured in terms of the wavelength of cadmium light. It suffices to say that this technique is one which has been developed to a very high order by physicists, and those who are pursuing an Honours degree in Physics will be familiar with it.

Good though this is as a standard, it is not perfect, and academic research in the field of optics and atomic theory has shown that the light emitted by the cadmium atom is not exactly of one wavelength, but actually consists of slighly different wavelengths which are very close together. However, the light is much more homogeneous than those from, say, mercury atoms. This fact sets a limit to the accuracy which is obtainable for all measurements of length, i.e. all industrial gauges cannot be more correct than this limit set by the spread in the vibrations due to the best cadmium which can be produced (Fig 4).



From "Physical Optics" by R. W. Ward.
(Courtesy of the publishers—The Macmillan Co., New York)

Fig. 4. Effect of fine structure on Interference Fringes. (above) Repetitive haziness due to presence of two wavelengths. (below) Large number of Fringes clearly seen with Monochromatic Light—i.e. single wavelength is used.

At this point we enter the realm of highly academic scientific research. In fact, we enter the world of nuclear physics. Research in universities has shown that the reason why the radiation from mercury, or even of the purest form of calcium that can be prepared, is not exactly of one single wavelength, is because there is more than one kind of calcium atom and these cannot be separated by chemical processes. Now precisely the same problem has to be faced in the preparation of the isotope of uranium 235 used for the atomic bomb, and the methods which have been developed by physicists for the separation of atoms which only differ in weight by a small amount for use in preparing the atomic bomb, can also be used to separate the isotopes of other atoms for peacetime purposes. Thus, atomic research establishments such as our own at Harwell have been able to prepare for industry comparatively large quantities of these precious isotopes. The industrial significance of this is enormous. It has been found possible to isolate and prepare in sufficient quantities a single isotope of mercury, which emits a spectrum line better in quality than the red cadmium line which has been considered to be the best until now. So we can

see how research in physics, which is at the very limit of our knowledge, has an immediate and practical effect on the problems that beset the Production Engineer. Fine measurement is a field of research in physics which occupies the attention of a large number of people, and their work has a direct effect on the manufacture of countless numbers of accurately machined parts. I think it would be true to say that the expert in fine measurement is only just able to keep one step ahead of the demands made upon him by the continued development of production engineering.

Inspection Statistics

In conclusion, there is another very important way in which scientific ideas can help the Production Engineer. That way is to use as fully as possible the results of mathematical statistics. Now in referring to that here I do not want to suggest in any way that what I am saying is new or unknown in industry—far from it. Most of the big industrial firms have highly competent statisticians on their staff, whose business it is carefully to watch and analyse the production processes and trends, and all I shall say now is in many quarters thoroughly well appreciated and used. The reasons for referring to it here in this lecture are, firstly, that no talk on science and the Production Engineer would be complete without emphasising the enormous help, I might almost say, under modern conditions, the *essential* help, which can be given by the full understanding and application of mathematical statistics in industry ; and secondly the fact that although up-to-date firms are using these methods today, nevertheless many firms, far too many under modern conditions, still appear to be unaware of the enormous advantages to themselves which follow from an appreciation of statistical methods. To illustrate my point I will give an account of a procedure which was found of inestimable value during the war, i.e. the application of statistics to inspection.

Under modern conditions of quantity production, one of the problems that confront the Production Engineer is that of inspection. Each part of a manufactured article must conform to certain specifications. These specifications are designed to ensure that all the parts can be successfully assembled together to form the complete article, and also to make certain that the quality of the final product does not fall below certain pre-determined standards.

One way to achieve these ends is what is known as 100 per cent. inspection. Every single part is examined and passed if satisfactory and rejected if not. There are some cases in which this must be done. It is easy to think of examples in which such close inspection has to be carried out, as it must when the failure of the product would lead to loss of life or serious damage to plant or machinery. There are other cases in which 100 per cent. inspection is clearly

impossible, as it is when the only known reliable test means the destruction of the product. Between these two extremes there exists a wide range of conditions in which complete inspection is uneconomical. It is in these circumstances that the full resources of modern statistical method can be brought to bear on the inspection problem.

I will give an example of a particularly successful method which was developed during the war. This method is known as *Sequential Analysis*. Suppose that it has been decided that the most efficient way of manufacturing a certain machined part in quantity is to adjust the conditions so that, say, 95 per cent. of the parts are within the required specification, while 5 per cent. are discarded as unsatisfactory. This is a common situation. It may be very difficult to plan the work so that every single part that is made is acceptable; and it may lead to large saving in time and cost if the aim is not absolute perfection but something rather less. The small wastage in allowing a modest proportion of unsatisfactory work may be economically preferable to taking a great deal of trouble to ensure that everything that is made is passed.

We suppose now that the manufactured parts are inspected in batches, and that the level of 95 per cent. pass has been agreed upon. The inspector has a sheet of graph paper on which two limit lines are drawn diagonally across the paper, the origin of co-ordinates lying in between, as shown in Fig. 5. The inspector tests an article from

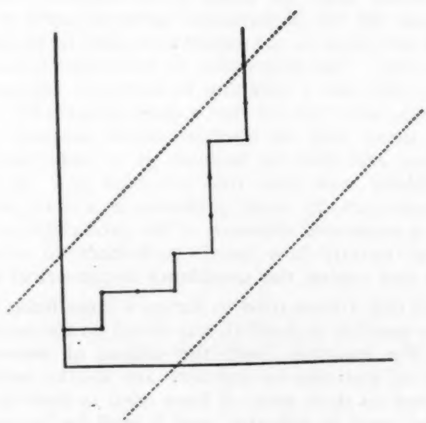


Fig. 5. Graph for Sequential Analysis.

the first batch. If it is satisfactory he draws a vertical line one unit in length starting from the origin. He now takes another member of the batch and, if this is unsatisfactory, draws a horizontal line one unit in length, starting from the end of the first line. He continues this process, obtaining an irregular staircase-like graph, drawing a vertical line every time he passes an article, and a horizontal line every time he rejects one. Sooner or later, the graph cuts the upper or lower limit lines. If he cuts the upper line the whole batch is passed; if the lower, the batch is rejected.

Conclusion

We see therefore that it is possible, on the basis of statistical reasoning, to devise methods whereby an inspector can say with confidence whether a quantity of manufactured parts are 95 per cent. satisfactory or not. Of course, the actual figure of 95 per cent. is one which we have taken as an example.

There are a number of refinements of the simple scheme we have outlined which we shall not discuss in detail. The important idea is, that once we concede that it is possible to be content with probability rather than certainty, powerful methods are ready to hand to enable us to deal with situations that arise. Again, human fallibility being what it is, it is often difficult to speak of certainty. A scheme involving 100 per cent. inspection can easily lose all claim to infallibility, if it is so difficult or tedious as to lead to error on the part of the person responsible for its execution.

A point which must be made here concerns the theory of probability and the use of statistical methods based on it. There is no lack of precision in the arguments used in probability and statistical theory. This impression is sometimes created because the language used has a meaning in everyday conversation. In ordinary speech, when we say that a given eventuality is probable, we generally mean that we have intuitively assessed the various relevant factors and that on balance, it is more likely that the eventuality should arise than that it should not. A statistician, however, always uses the word probable in a very precise sense. He can give a numerical estimate of the probability of an event, and he knows exactly how much confidence to attach to his estimate. He can express this confidence in numerical terms.

In this short talk I have tried to survey a large field; of necessity it has not been possible to dwell in any detail on the various aspects considered. For example, both the subject of measurement in industry and of statistics in industry are worthy subjects for a complete lecture on their own. I have tried to show how Science is, and can be, used in industry, and I shall be happy if I have stimulated Production Engineers to give sympathetic consideration

to the help which they can obtain, and the benefits which would accrue from a full understanding of basic scientific ideas as well as of some of the more recent developments in Pure Science.

To conclude, I wish to acknowledge my indebtedness to Mr. M. R. Hopkins, Imperial Chemical Industries Research Fellow in my Department, for much helpful discussion.

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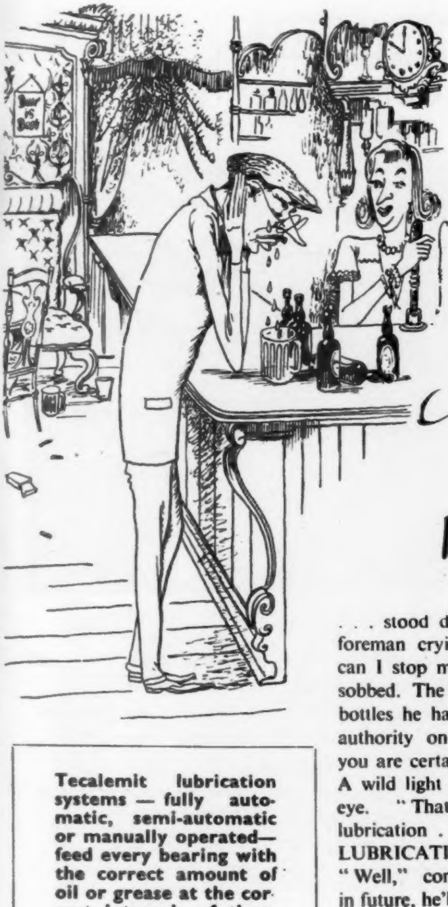

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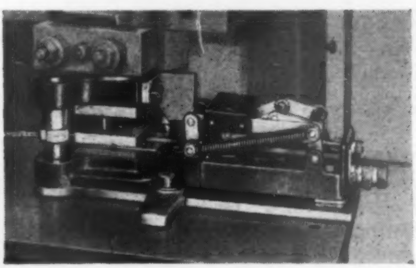

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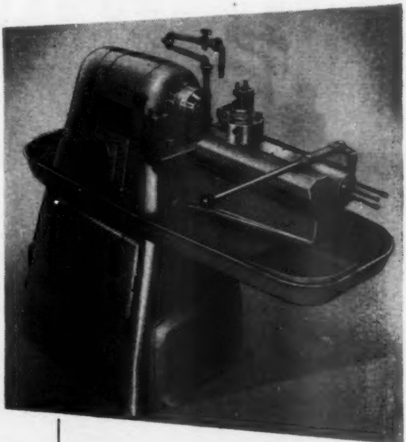

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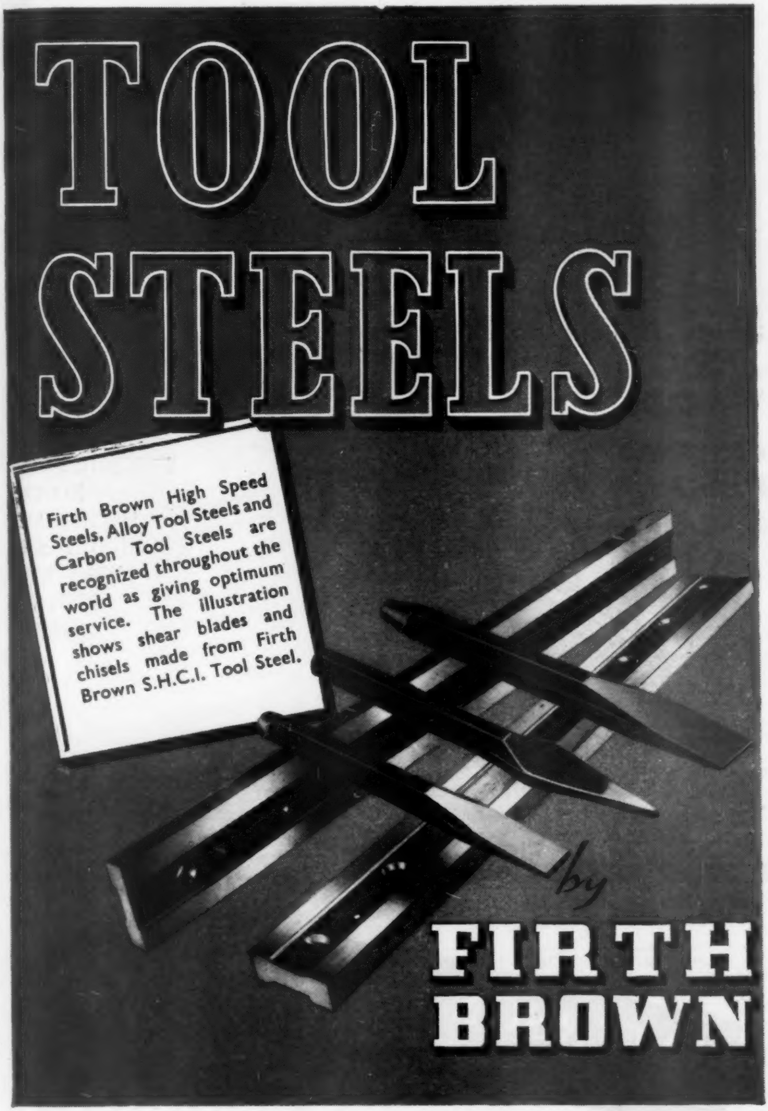
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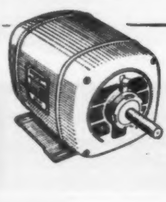

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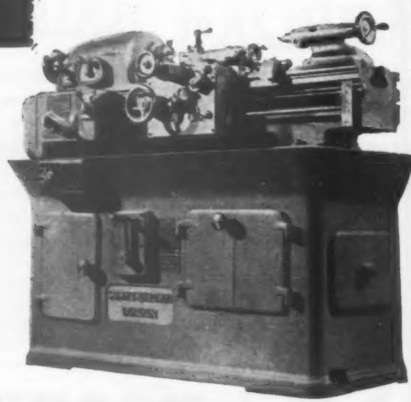

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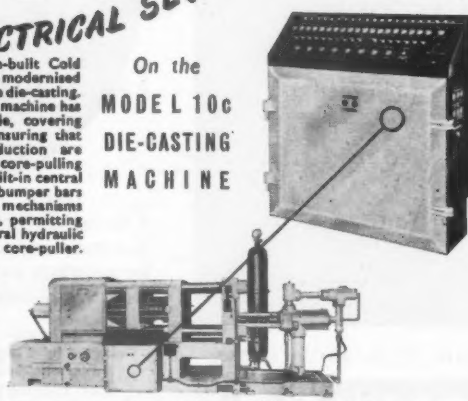

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